Libyan Desert Glass Structure

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History: 12/29/2024 - draft
1/13/2025 - version 0.50
3/13/2025 - version 1.60
4/30/2025 - version 2.71
12/21/2025 - version 3.127

Other Work: The Passionate Ape
The Crash of Flight 706

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Introduction

Thirty million years ago an obscure event liquefied snapshots of undisturbed silica sand. In what was subsequently named the Libyan Desert, the resulting Libyan Desert Glass (LDG) preserved and now exposes a natural grain-stacking process in dune formation. This phenomenon seems not to have been recognized or described before, and its physical manifestation has been misunderstood.

The origin of this glass has two competing narratives, which together form a consensus on a meteor impact or near-impact. Both narratives agree that a violent event of shock and heat melted a varied surface of sand, sandstone, and incidental rocks. I propose instead that it was formed by an intense blast of beta radiation, that there was no more than moderate heat, and the sand was not melted but merely wetted and bonded.

Many (but not all) LDG specimens are not true glass, but are welded bundles of fine parallel silica crystals, analogous to sheaves of uncooked pasta noodles. In this informal document I propose two hypotheses to explain this phenomenon, and why it was misunderstood. I suggest that loose sand blown by the wind may create both varve-like planes a few grains thick, and proto-crystals like beads on a string, which can be captured and frozen under the right conditions.

Two types of evidence support my model. First, specimens display sand grain rows and lattice chains that survived the creation event. Second, specimens contain delicate fossils, including imprints of leaves, preserved plant materials, and underground insect nests, none of which could survive a meteor event. I will present samples in sequence to reflect those two evidence groups.

This discussion is not a blanket description of natural glass. The focus is one formative episode at one particular site, where an enigmatic radiation event happened to preserve an interesting and potentially universal phenomenon involving blowing sand.

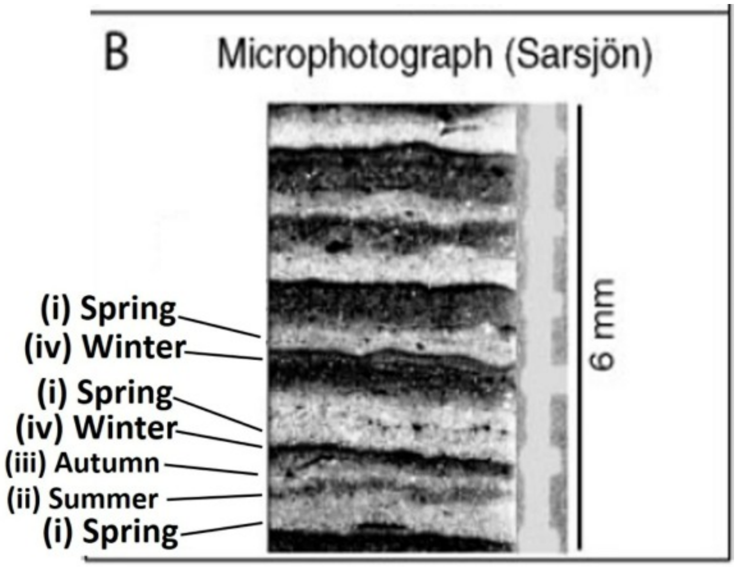
Thesis

I propose that blowing sand may develop two features that are not immediately obvious, are highly ephemeral and do not survive disturbance. These are (1) layers at the scale of one or two grains sorted by size (not necessarily within the same chemistry), along with (2) strands of sand grains, like gems on a necklace with no cord. These planes and threads are entirely obscure to us, and can be revealed only under special circumstances. I propose that the LDG formative event froze these invisible layers and threads, and time made them visible through weathering.

Significant hurdles stand in the way of showing this. My only examples are LDG, and LDG is not a homogenous body of blown sand, it includes sandstone and varied chemistry. Any one piece is not necessarily obvious about its state before it was fused. The fluid viscosity and duration are not obvious and are important. I lack the technical background and some needed equipment. So there are issues. But I'll try to make my idea clear, and put it out there.

I'll cover the planes first, and threads second.

Documents on LDG make offhand mention of planes within the glass. There are two obvious sources of planes - gross changes in stratigraphic chemistry, and layering as a relic of the sandstone origin of some LDG specimens. Sandstone being typically sedimentary, it would be unsurprising to find layers caused by seasonal changes in the coarseness or chemistry being laid down. The two images below show layered changes in the glass chemistry in one of my samples. The left appears to show sand or sandstone alternating with quartz and some kind of dirt. Such layer changes could be long-term changes in deposition, or debris from an underwater slump or similar event. The right shows a thin and wispy discontinuous layer within the upper clear part of the same sample, and I'd provisionally call it a little silt laid down along with the sand in water.



The other expected layering comes from the sandstone's formation, perhaps in water, perhaps on land. In water, layers can form as varves - created by seasonal changes in deposition. This can be changes in the coarseness of minerals, such as larger grains in spring runoff into a lake, and smaller grains when the flow is slower. It might be seasonal changes in chemistry, with biomass being deposited at some times and not others. The above image on the left is microscopic layering from a lake in Sweden, while the right image shows much larger scale layering in sandstone.

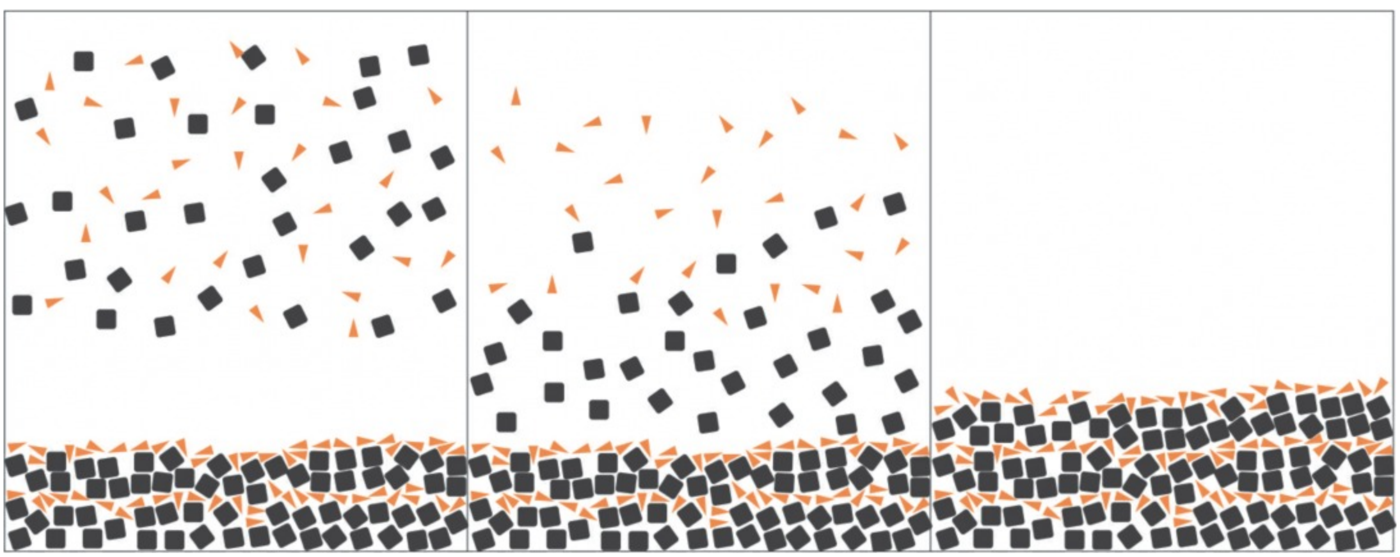
Sandstone can also form layers as petrified dunes, where sand already laid down by wind is wetted by a rising water level, and grains are then bonded by calcium carbonate for example. Layers in dunes may be formed as slumps on the lee side, as sand building on the windward side periodically slips down. This can sort grains by size. These slumps can later experience rising water levels, dunes can be submerged, invaded by sediment and bonded to form sandstone. These processes can preserve the slopes in which the sand was laid down, as in the following image.

I am proposing something quite different, layering at the scale of one or a few grains, and in a span of seconds, as sand flurries blow in and settle down, or as loose sand in a breeze creeps and bounces along the surface. Each puff of wind may carry sand grains, smaller fragments and dust. The larger grains settle quickly, followed by fragments and dust. This creates layers not normally noticed, not visible to the naked eye, each a few grains thick.

If this layering does in fact happen with blown sand, perhaps it's old hat to geologists. It would be easy enough to test for. One way would be to press a strip of packing tape onto loose sand, pulling up the top layer. Successive strips of tape would take additional layers, each a horizontal slice of the sand dune, to be viewed and tallied under a microscope. These would not correspond exactly to layers as laid down, which must vary in thickness across a sample, but would more resemble how tree rings look when cut into veneer for plywood. Still the pattern should be clear enough. Another test might be to pour glue or acrylic into a few cubic inches of blown sand, and then cut and polish vertical slices of that for viewing.

I suggest the different layers of large grains compared to dust and fragments will offer different levels of resistance to weathering after the loose sand is bonded as glass. The ability of grains to retain any coherent crystal structure will depend on how thoroughly the liquefaction and bonding occurs. Where there is any persistence of the individual crystal lattices, this should give higher resistance to chemical attack. The same higher resistance should act in the case of mechanical abrasion, being more difficult to break atoms loose from a matrix than from an amorphous blob.

If I've described a real phenomenon, it's probably part of the first year geology lab. Lacking training in the field, I am merely trying to describe what to me are possible explanations for something I found in my samples.



My second conjecture is that blown sand forms threads. I suggest that the static electricity induced in blowing sand creates a magnetic field for each moving grain, and this magnetism causes grains to align in their lowest energy state as they land, creating depositional threads like loose beads lined up in a crafting tray.

When grains melt to glass lightly enough, or are wetted in place by liquefied silica, this alignment causes the strands of grains to predispose to crystallize following any surviving lattice alignment. The lattice of the grains is the seed for the entire crystal. Where there is insufficient time to crystallize, any surviving grain structure still creates corresponding domains of strength with respect to abrasion or chemical etching. I use the terms “crystals” and “threads” to distinguish between these two states for the scope of this discussion. A crystal is a bonded string of grains sharing a healthy lattice with minimal discontinuities. A thread is a string of grains with individual lattices aligned, either before bonding, or after bonding with many discontinuities or even no lattice shared between grains.

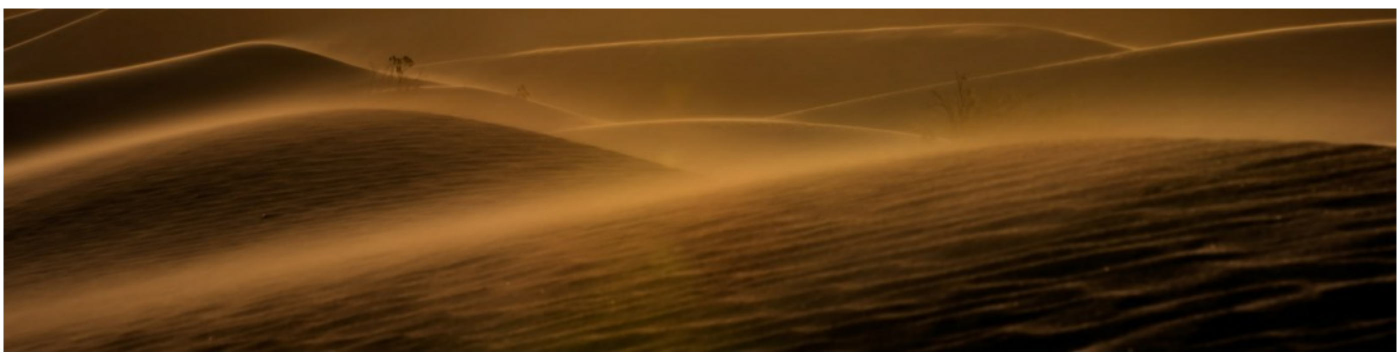
Blowing sand generates electrical charges. At high and low densities of sand and dust, these charges tend to dissipate. At medium densities, sand and dust grains accumulate charges as they collide, in effect converting the kinetic energy of the wind into electrical charges. This is the source of lightning in sandstorms. Lightning dissipates some but not all of the static electricity, when it reaches high enough level, but the sand grains still retain a charge.

Dust Lightning

This charge persists near the surface of disturbed sand and in grains newly fallen from sandstorms. This charge may also start when sand is blown along the surface, without rising to the level of sandstorm. As the breeze grows, grains first roll, then bounce, colliding and accumulating charge. As the breeze continues to move them, the charge may build to the level that gives electrostatic repulsion, and grains become airborne. In effect, the electrostatic effect may appear from the top down, or grow from the bottom up.

The voltage of the electrostatic charge can be estimated by the reluctance of sand grains to settle to the ground. The sand that seems to float above the ground comes from two sources - simple kinetic energy as falling grains hit the ground and bounce, and electrostatic repulsion. This repulsion can tend to lift grains, to slow the initial fall, or to prolong a bounce. A bed of sand is notoriously yielding to impacts, so a bounce is possible only where it is assisted by the electrostatic repulsion - where the grain is nearly weightless. The thickness of the airborne sand layer just above the ground shows the electrostatic voltage in play.

The sand grains falling to the ground are not merely charged, they are polarized, and this moving charge produces a small magnetic field. The magnetic field in turn induces a magnetic field in the recently arrived sand grains which still retain a charge of their own. So while the incoming grain is moving, both it and the grains on the ground are magnetized according to the polarity of their respective charges.



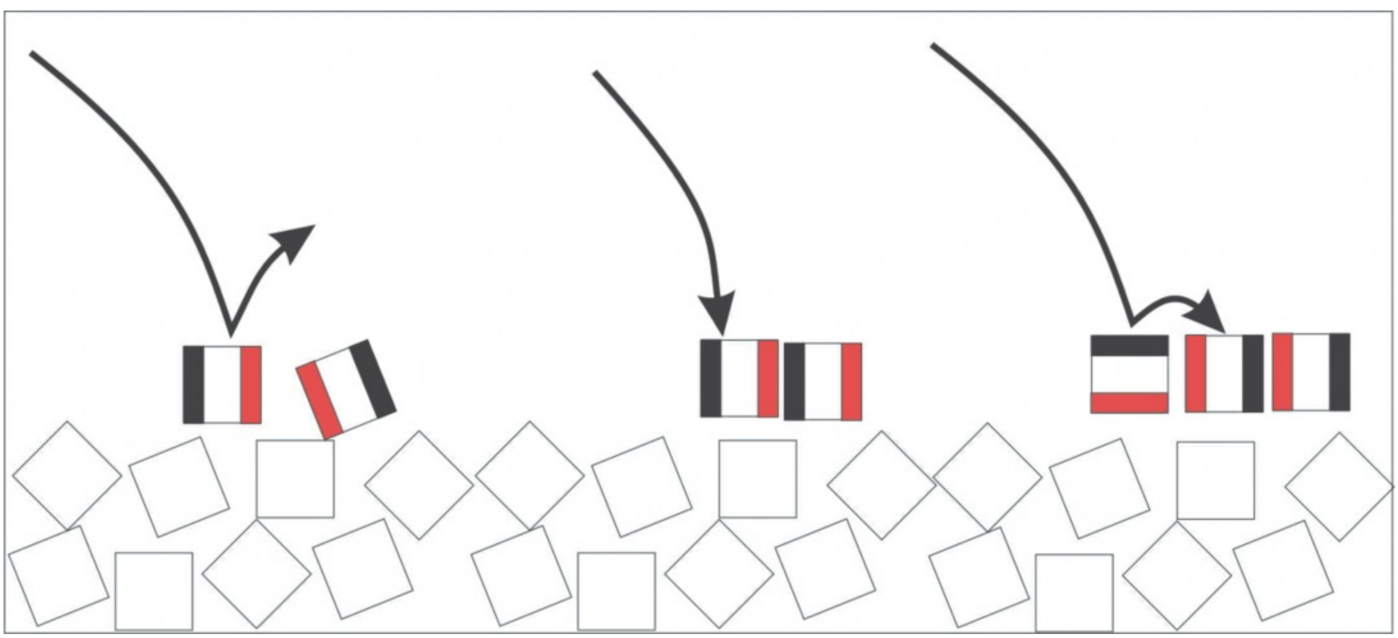
Charged sand grains resist falling to ground

An incoming grain will bounce until it dissipates enough energy to sit. It will be somewhat less likely to bounce if it lands next to a grain that has the corresponding magnetic polarity. It will also be less likely to bounce if it lands near a grain close enough in polarity that the arriving grain can roll or be drawn into a compatible position. Once the incoming grain stops moving, the magnetic field disappears but charge remains, dissipating slowly.

This effect becomes more prevalent as more sand arrives and settles. Recently arrived sand carries charge which is dissipating into the ground. New arrivals looking for a place to land, if you will, carry the same charge. They are electrostatically repelled by the prior arrivals on the ground, the force depending on the charges in each group. So new arrivals tend to float to a degree, and the float lasts longer as the sandstorm progresses or the breeze continues.

An arriving grain may touch down in relative isolation, or adjacent to an already-stationary grain. If the at-rest grain is orthogonal to the arriving grain's travel, the arriving grain is more likely to go on. But if the arriving grain butts up against a stationary one with an auspicious orientation, it could start a column of grains growing in the direction from which they are coming. In other words, if I am describing a real phenomenon, sand columns or threads should align to the wind and grow against it.

The propensity of a given sand grain to take a charge depends on the chemistry of the grain. For any given grain, the tendency of that charge to have one polarity vector and not some other orientation seems to owe something to the crystal structure, with perhaps some considerable slop in its precision. This suggests a thread of grains will share a common orientation of their member lattices, more or less. I don't suggest that sand grains will sort themselves among threads according to their chemistry or purity, but only that threads (if they form as I propose) do so because they fall into a common lattice orientation.

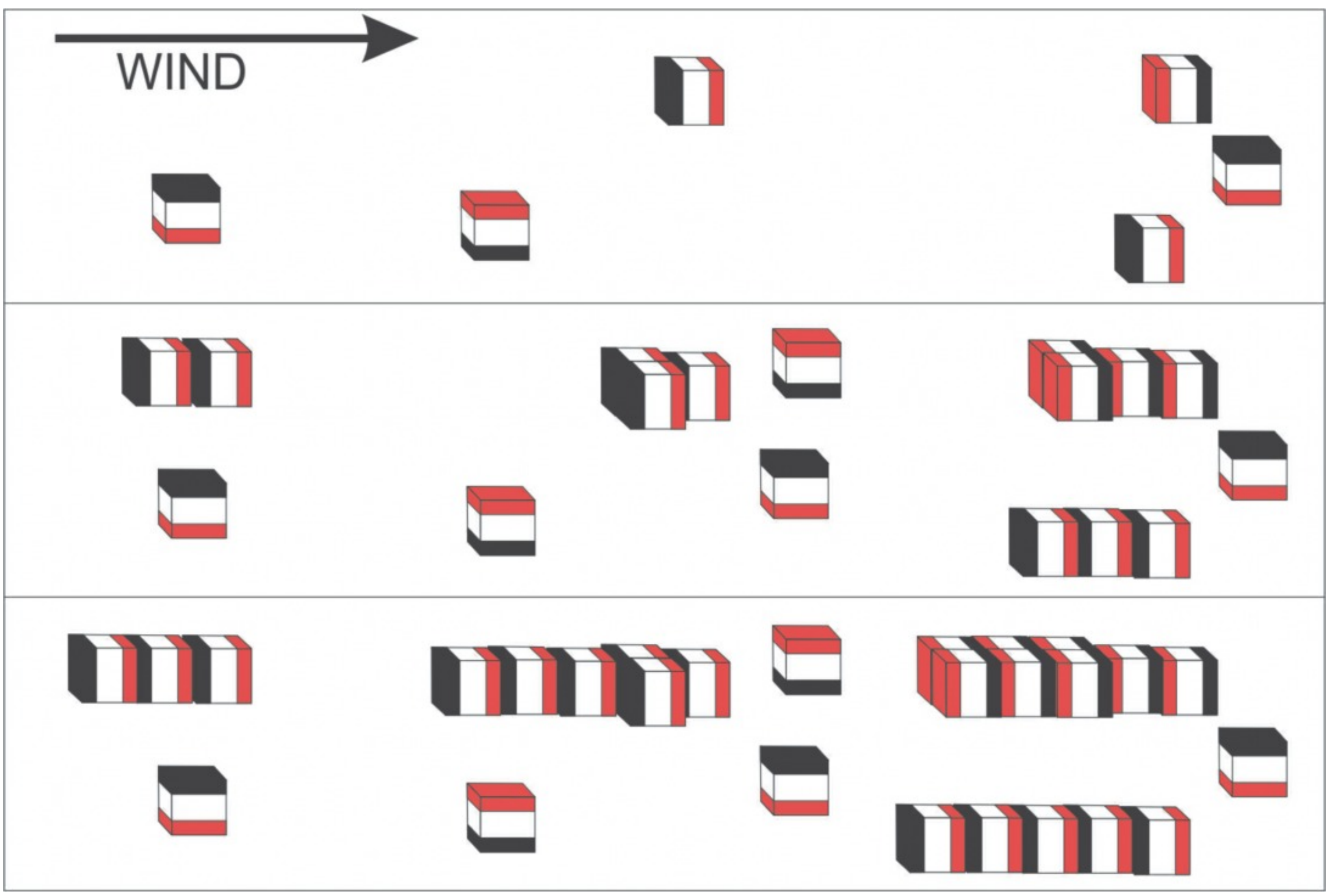


LDG is characterized as high-purity silica sand, but there will inevitably be some mix. A quartz interloper may stack onto the growing end of a chain, satisfying the electromagnetic requirement but interrupting any single crystal that can form from that chain. And the propensity to form this chain depends on the level of static being generated in any specific sand-laden breeze. So I am describing an intermittent process of unknown frequency.

In sum, I suggest that sand grains will tend to electrostatically float as they approach the ground. They will settle (albeit reluctantly) where they find the least resistance, meaning in the company of earlier arrivals with a compatible magnetic orientation. This will frequently give threads of grains with lattice alignments which agree.

I am not suggesting that this phenomenon will invariably happen. The tendency of grains to take a charge depends on the density and speed of the wind-blown sand aloft. The tendency to chain up when landing depends on that charge, on the density and wind speed in the landing zone, and on charged grains that previously landed. So I don't assert that LDG will always display crystalline structure of multiple sand grains, but only that when it appears I have fairly surmised how it formed.

These mechanisms may work in conjunction. Where a breeze lofts sand grains and gives them charges, finer fragments will also be charged in the same way. The tendency to settle varies by weight, but the reluctance to settle depends on charge. So threads of grains may concatenate on the surface as the magnetic charge guides them, while smaller fragments float overhead slowly adding a finer layer, a puff of wind at a time.



This process may also work on a larger scale. As grains arrive and concatenate, I described them as slowed in their descent by the total electrostatic charge on the surface, pending dissipation of that charge over time. But that total charge also represents the sum orientation of the grains already in situ. So arriving grains are not seeking simply a compatible thread, so to speak, but are being oriented by an electric field covering a broader space, within which they will find a locally optimal chain.

This could operate by synchronization at the grain level or by some more global principle.

If grains are meshing with arrivals already on the ground, it would begin with the local field of a few grains, affecting the orientation of some grain landing nearby but not close enough to join a chain. This spawns a new chain with the same electromagnetic orientation. As such chains form, they form a wider field, and increase the tendency of the next arrivals to spawn similarly oriented chains, growing a domain with a common pole. This domain may take over a large part of the dune, as smaller domains with different orientations fail in the race to attract new adherents. Such a process would tend to result in a few large domains, even if the orientation of initial arrivals is entirely arbitrary.

Grains could also mutually align in the air, and could be oriented the same before ever arriving at their landing zone. This might be by the growth of domains starting with arbitrary orientations, as in my description of the destination dune. When such clouds of aligned grains arrive at a landing zone, the magnetic orientation of the deposited sand may be directed, in effect, by the airborne mass.

Alternatively, airborne grains might align to earth magnetic fields, or some electrostatic orientation characteristic of sand storms unrelated to earth fields. Wind injects electrical energy into grains, and there may be some windstorm-level phenomenon that controls how those charges are oriented, as in the leading edge is North or some such. Also, the mass of charged grains moving through the air is moving in the earth magnetic fields. The cloud may take polarity from that, and in turn the particles. So the orientation of charges on the ground might be a direct result of wind direction or the global magnetic field.

If any of these larger-scale processes are in play, it should be easy enough to measure. Devices that can record magnetic direction and strength can be sited in an area of sand dunes, and should give immediate indication when wind-blown sand is being deposited. Similar readings are possible inside airborne sand clouds, and related experiments began in the 1940s exploring radio transmission. None of these orientation patterns are evidence of the cryptic crystals, but they do flesh out a conceptual background for that crystal formation.

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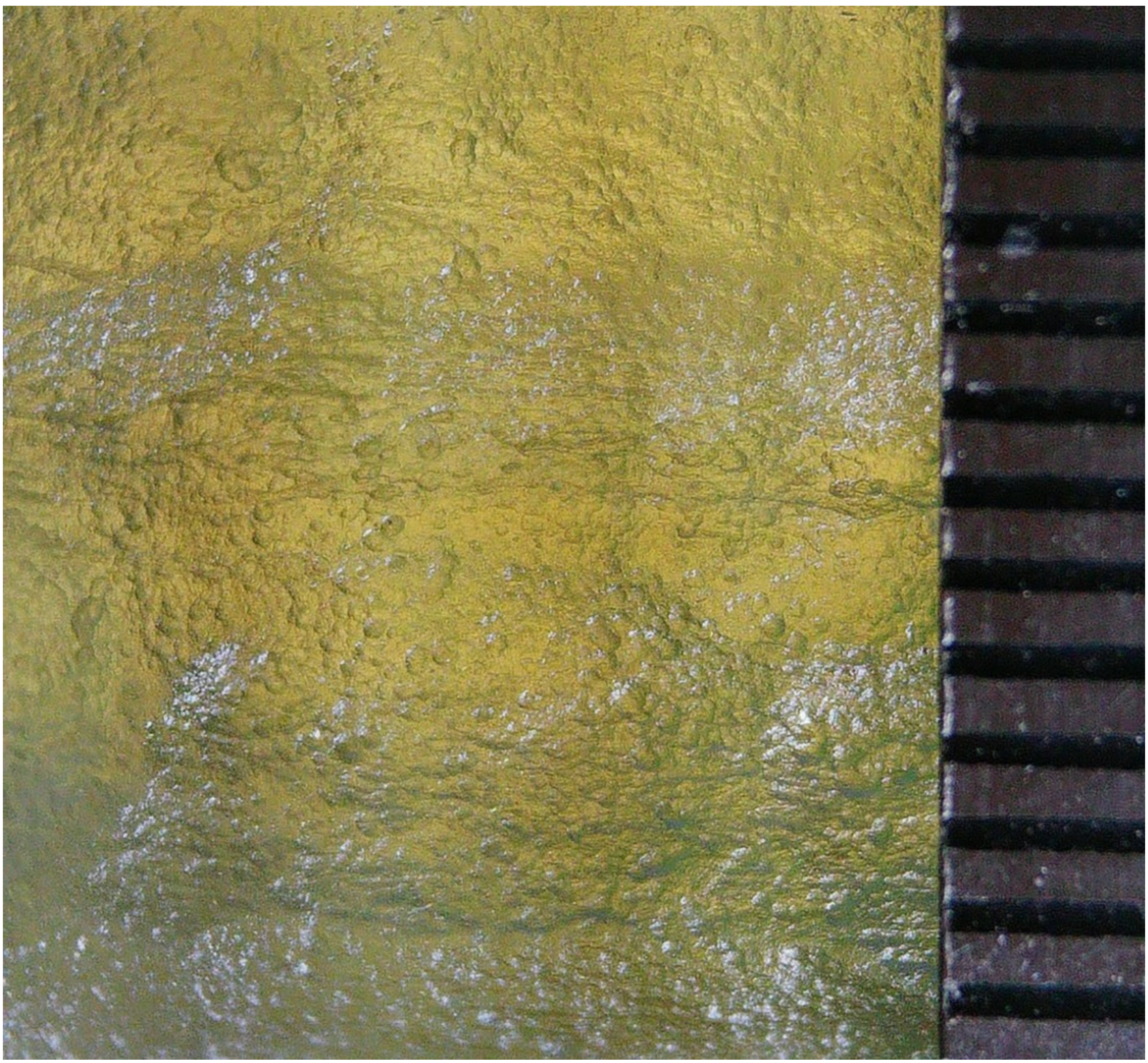
I found structures in my samples of LDG, and have proposed two mechanisms to explain them. There might well be some other explanation for what I'm seeing. I will use these two models to discuss the morphology of my samples, pointing out what fits.

The basic issue is that there is a significant level of detail being exposed in LDG by the weathering process. LDG is a glass, and I would expect it to break and weather like glass. When glass fractures it displays a characteristic curving surface called "conchoidal", derived from a Greek word for a sea shell shape. Several minerals lacking cleavage planes, or whose cleavage plane does not line up with an impact, can fracture this way. Examples are flint, chert, and window glass.

LDG is commonly described as having no crystalline structure. But crystals are primarily a product of slow cooling. Where lava cools quickly it gives obsidian, when more slowly it gives rhyolite with crystals mostly too small to see, when more slowly still it gives granite with visible crystals, and so on. In all these forms the crystals are effectively random.

LDG does indeed often fracture like a glass, but after weathering it may display fine striations as if it has a structure approximating planes or fine linear crystals. Crystals that uniformly line up with sand as laid down, and which are at the scale of sand grains, suggest the liquefied sand retained the seed for the crystals in the survival of individual grain lattices. I don't assert that all LDG must contain cryptic layers or parallel crystals; perhaps most does not. But where it does have either, there was some phenomenon that created them, and that's what I'm looking for.

This image shows LDG with a scale in millimeters, and up to six horizontal lines per millimeter are visible near the image center. I suggest we are viewing the fine structure of an ancient bed of loose sand, captured by a liquefaction event and made visible by weathering. Thirty million years ago a breezy day was captured in glass like a puff of air in a bottle.



Natural Glass

Natural glass appears all over the world. Obsidian is of course volcanic, and not of interest here. Fulgurites are created when lightning strikes the ground and creates tubes (generally) of fused minerals, and are also not of much interest here, but see below.

Some naturally occurring glass consists of tektites thrown up by meteorite impacts. A tektite is molten splatter from the meteorite or the ground it strikes, typically found as gravel size, thrown considerable distances and sometimes into low orbit. This may cool soon after it is launched, and it may go high enough that it heats again on re-entering the atmosphere. Tektites are typically glassy, since they are melted minerals. Moldavite is a glassy dark green tektite from a known meteorite hit 15 million years ago in southern Germany. This and other tektites have become popular for mystical purposes, so there are many fakes.

Some natural glasses have been designated pseudotektites, a more or less informal label. These superficially resemble tektites, being typically dark and pitted, but don't seem to be impact products. Pseudotektites are mostly translucent and may appear layered, while true tektites are not internally organized. Pseudotektites have sometimes been interpreted as flow-layered obsidian. They have no origin consensus; it's a term of convenience for a group that is not rigorously defined.

Air-bursts of meteors or comets (as in the Tunguska Event or Chelyabinsk) are a source of naturally occurring glass, where the heat radiated from the burst is enough to melt minerals. An air-burst might be a high-altitude explosion of an obliquely entering meteor with effects limited mostly to shock waves. But they can scale up to low-altitude near-impact explosions which may be almost indistinguishable from full impacts in the geologic record. Such low-altitude events may generate a wider heat signature and more natural glass than an actual impact.

Obsidian, fulgurites and impact glasses are well understood, but a new scope of events related to geomagnetic fields has been recognized as potentially significant. Recent developments have made it clear we are in the early stages of a magnetic pole shift or excursion. This has been well publicized in the form of auroras being visible in lower latitudes. While this is spectacular, it is also a sign of our magnetic shield failing.

Theoretical work has indicated some of the geophysical forces that might be unleashed in the process, and these are now beginning to appear. One result is chaotic electromagnetic fluxes generated as the earth's weakening magnetic field ceases to buffer the solar wind, cosmic rays, proton stream, and coronal mass ejections. Solar emissions which were once trivial are now causing geomagnetic storms. This weakening allows our magnetic shield to be pressed down nearer the earth on the sun-facing side, and raises the possibility of electrical surges near ground level.

We have seen this already, when the entire Iberian peninsula was taken down for several hours recently, apparently by a solar event that (given a healthy magnetosphere) should have had no effect. A similar event took down Quebec for nine hours in 1989. As our magnetosphere continues to weaken, and our magnetic poles continue to wander, the threshold for significant impacts will drop in response. Over the next few years, it will require ever milder solar outbursts to cause major problems on earth.

These geomagnetic forces may create natural glass. The process starts with the electromagnetic paths spanning the globe north to south, constraining a constant flow of low-energy particles that bounce from end to end without touching the ground. The magnetic field traps solar particle emissions and cosmic rays, and deflects them into joining the north-south bouncing. These particles move fastest near the equator, while near the poles each particle gradually slows, stops and reverses direction. If the magnetic field weakens, this cloud can lower to near ground level, and given the right conditions it may directly contact the ground at its ends or along its length.

I am well beyond my depth in reverse-engineering a source for beta radiation. This radiation involvement came up in the course of my exploration, and the particle cloud and magnetic field seems like a possible explanation. But this is not my field and there could be something else entirely going on.

Beta radiation at high enough levels can liquefy silica, both amorphous and crystalline. Beta radiation sufficient to liquefy crystalline silica is in the giga-Gray range, but lower for amorphous silica. This is not melting sand, but making it liquid for the duration of the radiation event. As an analogy, silica becomes liquid under beta radiation like damp sand becomes liquid when you tap it with your foot.

Beta particles have limited penetrating ability, and are normally stopped by a few millimeters of aluminum. Alpha particles are stopped by a sheet of paper, and gamma rays take inches of lead or many feet of concrete to stop. This suggests that beta particle bombardment might resemble flash heating: It will be very intense on an exposed surface, and will drop off exponentially with increased depth. Beta radiation on skin can cause sunburn. With respect to the silica, this makes beta radiation a close functional match to a fast heat event, but without the heat.

My specimens seem to show that the glass was formed by beta radiation, and the effect was near ambient temperature. This should become clear in viewing the individual samples, but we need to start here with the beta radiation introduction. I will propose two ways the earth's particle cloud might create this radiation on the ground.

The magnetosphere particle cloud is essentially beta radiation, safely confined above the earth. While the sun is not a strong source of beta particles (i.e. electrons and positrons), the cloud functions as a beta particle accumulator.

Near the poles these particles create the auroras, the most obvious sign of our weakening magnetosphere. Typically the particles are eventually netted by the atmosphere, and the sun's energy that was pumped into the particle cloud bleeds off slowly. But if the belly of this cloud were forced into contact with the ground, it could be equivalent of an electric arc furnace, in contrast to the short duration of lightning. This would be most powerful halfway between the north and south magnetic poles.

With a weakening magnetic field, a grounding particle cloud might be triggered by even normal solar ejections. The chance of this becomes higher in a super-flare or other explosive event such as a micro-nova. This is a new area of science, and the possible forces to be encountered are not yet well understood. Micronovas have been observed on nearby stars. There is evidence that our sun has experienced these and is likely to in the future.

When the particle cloud belly gets lower, it contacts the upper atmosphere and transfers energy to atmospheric gasses, generating heat. This causes the atmosphere to expand upward during some solar events, and creates drag for low-orbiting satellites. I suggest this may be much stronger under some circumstances, effectively scrubbing a patch of earth clear for nearly direct contact.

Where a planet has no magnetic field to protect it, the solar wind can wipe it clear of an atmosphere. Where the wind (here the particle cloud) is given added leverage by a weakened magnetic field and strong solar output, the cloud may do the same for an area of earth.

Earth's atmosphere thickness has about the same relation to the earth as the peel has to an apple. When the particle cloud belly hits the atmosphere, it heats the entire column, in effect forming an air blister perhaps many times its normal height. The beta particles are moving at a low angle with respect to the earth, and as the atmosphere balloons up from the heat the beta particles come in from the side, striking the earth nearly flat through an air mass that has been rarified by heating.

A typical lightning strike has high voltage and relatively low current, perhaps 300 million volts and 30,000 amps for half a second . What appears to be a single bolt is often multiple strikes, since the first strike creates a path of ionized air which is then low-resistance, and succeeding strikes follow that path. An electric arc furnace has low voltage and relatively higher current, a few hundred volts and perhaps 50,000 amps running for hours.

The particle cloud belly forced into earth contact might carry the equivalent of several hundred thousand amps. This is a blast of charged subatomic particles from the cloud equator, where they are moving fastest. If the cloud belly thins out a patch of atmosphere, the earth will be bathed in a cyclotron beam of particles at their highest energy state. The contact may continue until the earth rotates the connection out of the sun's direct pressure, at which point perhaps it jumps farther around the globe or breaks entirely.

I have no way of estimating how much energy is left in the particles after the atmosphere is thinned out of the way. The air is not completely gone, but is blistered up and and largely blown away, and will remain that way until normal forces of gravity and wind can return equilibrium after the event is over. So the beta particles do not have a clean shot at the ground.

If the particles are still at a high energy state, they would heat the ground as they are absorbed. Such impacts could occur through the earth's top layer of dirt or sand, through vegetation and forests, in the open ocean, and through the air near ground level. If such a particle surge were through ground that was at all damp, it would likely explode in steam and dirt-projectiles, leaving only a crater and some fused earth. There are anecdotal reports of such craters, but apparently no systematic tally. If through forests and vegetation, it would cause fires; catastrophic fires apparently do correlate to past pole-shift events. If the surface is arid, the particle cloud might melt the surface either by conduction or by radiant heat near ground level.

If the particle energy is attenuated by the remaining atmosphere, the radiation might be very similar to what I will describe next. For now, we might call this Low-Angle Beta Radiation: Low-density near-horizontal flow of particles dumping from the cloud, possibly retaining enough energy to generate heat.

The poles are the mirrors at the north and south ends of the particle cloud, funneling this flow down toward two narrow targets until it reverses course. The magnetic lines of force compress at each extreme, from the circumference of the earth at the equator to a few square miles at the poles. The poles are something like a basketball hoop. If a ball drops in at the right angle, it will spin around and go back out. Not a bounce, but a reversing. That's how particles turn back at the poles, not by actually bouncing but by being squeezed in their spin by tightening magnetic fields, dropping steeply down until they slow, stop, and reverse back up.

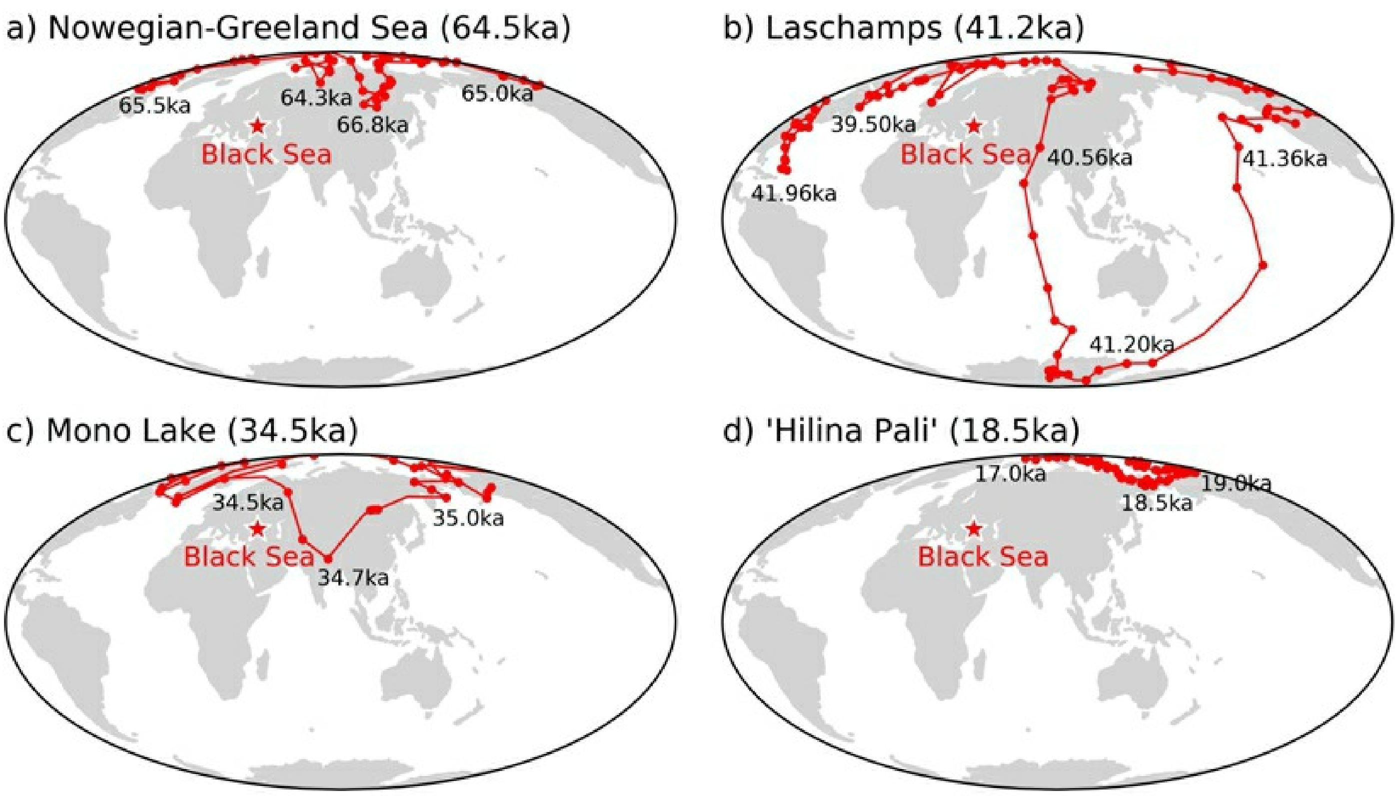
During a magnetic pole excursion, this magnetic funnel may be pointing at varied spots on the earth's surface. These locations are not random, but they answer to forces that we are only beginning to understand.

If the energy of the particle cloud is high enough, if the cloud is pressed down toward the earth enough, then the reversing fails to occur before the particles reach the ground. If grounding happens at a magnetic pole instead of around the belly, the particles are nearly stopped and at their lowest level of energy. So a magnetic pole may pour out beta radiation from the earth's particle cloud at its lowest voltage but its densest concentration.

We might call this High Angle Beta Radiation: High-density near-vertical flow of low-energy particles.

Whether the beta radiation that formed LDG came from the particle cloud's belly or the pole, my samples indicate that its effect was near ambient temperature. So if it was Low Angle, then the particles' energy was apparently attenuated by the remaining atmosphere.

We have two general narratives for the LDG formative event: A meteorite impact or air burst both involving heat and shock, or high intensity beta radiation with neither shock nor heat. The first has been the focus of virtually all debate on the source of LDG since its scientific discovery. The second I propose here for the first time. I lack the credentials to weigh the beta radiation alternatives, but they are necessary. They are geomagnetic phenomena plausibly associated with the earth's weakening magnetic field and the pole excursion currently in progress, so they are not without foundation. The choice between heat-and-shock and beta radiation is the backdrop for this discussion.



Magnetic North Pole Excursions in the Last 65,000 Years

Libyan Desert Glass

The samples primarily used in this document are claimed to be Libyan Desert Glass, which I purchased from a single seller on eBay. (A couple samples from China and Germany are shown for contrast.)

This seller appears to carry only LDG, and does not have any pieces which seem bogus. (I won't include pictures of clearly bogus samples out of legal concern, but you can tell.) I cannot independently establish the provenance of his merchandise. A recommended method of verifying LDG is to test the hardness against household items, which I did using a file. LDG typically measures Mohs 7, which I can roughly verify for my samples.

LDG has been characterized as variable combinations of loose silica sand, quartz, trace minerals, and fused sandstones with chemistry matching sandstones in the area where it's found. Some of the trace minerals are of typical meteorite chemistry, some are indicative of high-pressure impacts such as by meteorites. The predominant color is a distinctive greenish yellow.

LDG is widely sold as a gem, and the desirable pieces are typically clear, irregular but smoothed, and often the size of small gravel, perhaps half an ounce. I selectively purchased pieces with visible layers, inclusions, and rough surfaces. These seemed to carry more information, but would have less value as gems. I suspect it would be difficult to counterfeit the features I shop for and will be discussing. In short I have reasonable confidence but no proof that my samples are genuine LDG.

LDG has been dated at 29 million years using fission track dating, a radiometric method which gives a reliable measure of the date a mineral was last in a fluid state. This date is one reason to doubt that the magnetic pole shift or related events had anything to do with the origin of LDG. There have been thousands of those events since the LDG origination, and similar deposits should be broadly present where lands were arid during earlier events. We can guess that LDG's creation is at least not a typical event for magnetic pole excursions.

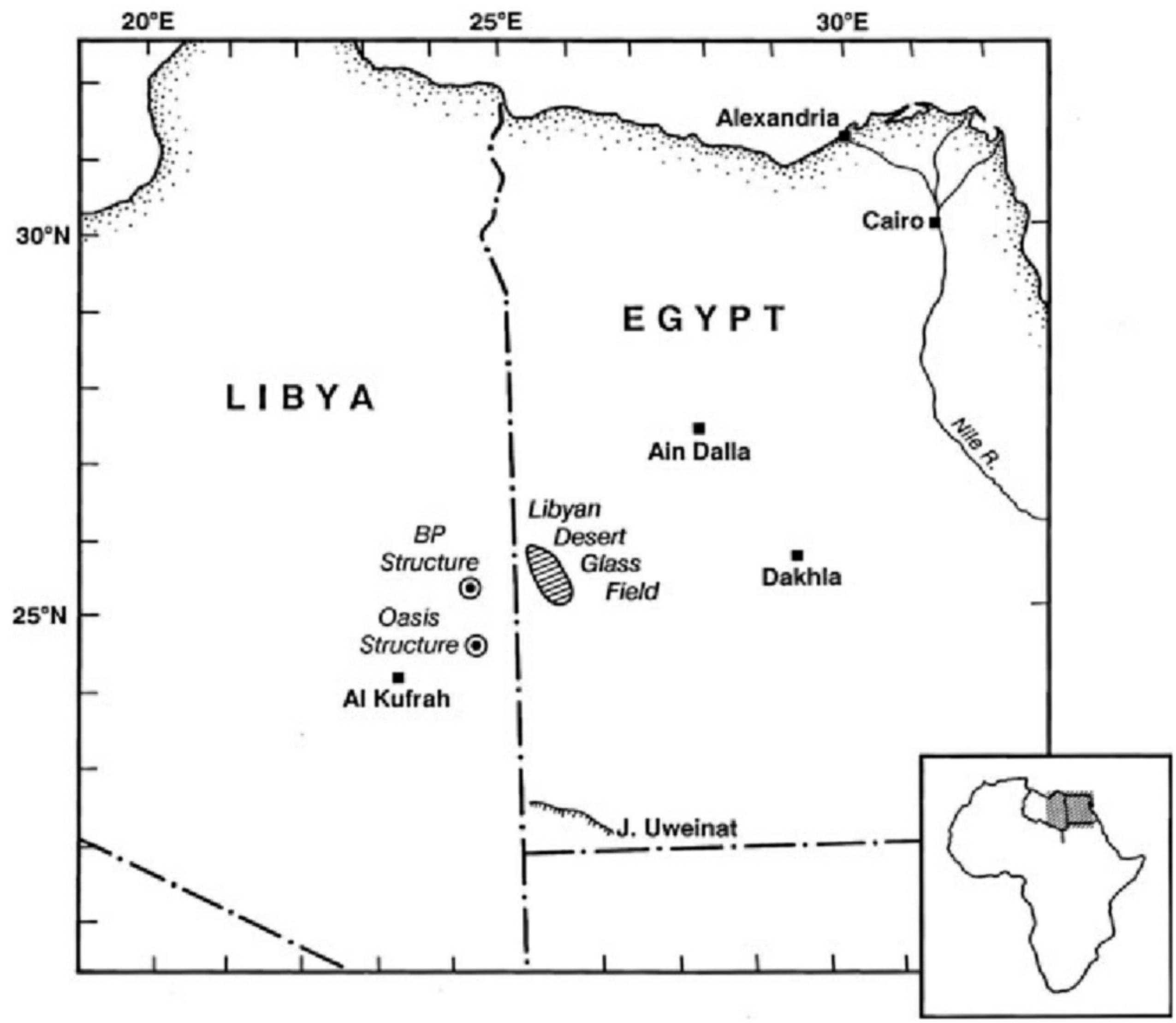
LDG is typically explained using two standard models for natural glass: Meteorite impact and air burst. This document presents my evidence that neither of those is an adequate explanation, and that a low-temperature radiation event has more explanatory value. This is not the thesis I came to town to prove; it pushed its way in during the course of study.

The meteorite impact is supported by the trace presence of characteristic meteorite chemistry in LDG, along with predominant components of a sedimentary precursor material. However, there are two undated impact locations near the LDG site, shown in the following map as the BP Structure and the Oasis Structure. Other impact sites have been tallied in the area. These may have salted the LDG original deposit before the creation event, leading to the trace chemistry.

Counting against the meteorite model is the lack of several typical indicators. There is no evidence of an impact structure. Though the glass has traces of typical meteor chemistry, there are no fragments of the meteorite. But the impact was apparently into a surface about 400 meters above the current ground level, and all that evidence may have disappeared with the erosion. Zircon has been put forward as evidence for an impact. But a recent report finds zircon in fulgurites, and the authors state that zircon can not be relied upon any longer as definitive evidence of an impact. Reports have stated that no other impact glasses show the purity or internal equilibria of LDG. If this is an impact product, there seems to be no other quite like it.

Finally, the total spread of the glass is oddly small to have resulted from an impact some 30 million years ago. Though the surface scattering mechanism is clear, a much larger field would be expected after that time if the initial debris were spread as much as a meteorite would be expected to do. By contrast, the LDG dispersion after such a time is said to be best explained by the original deposit being virtually a point source rather than an impact debris field.

An air-burst model is supported by the absence of an impact crater that could account for LDG, and the fact that LDG consistently looks like it was melted in place. It does not appear to have been splattered by a meteorite, but was heated as it lay, preserving internal layering and very large pieces. An air-burst sufficient to melt the LDG would theoretically be on the order of 100 megatons. An air-burst does not adequately explain some of the high-pressure chemistry found in LDG, such as zircon. The LDG origin event remains subject to debate ever since 1932, with the impact hypothesis being more accepted.



LDG Strewn Field

My suggestion that a radiation event be considered is the first such proposal, far as I know, and has no following at all. Evidence for my hypothesis is based on two grounds. First, LDG displays a mix of discrete sand grains and chains of sand grains in a silica matrix, as opposed to a roughly homogenous body of glass. A radiation event provides the explanation for this structure, while the impact or air-burst hypotheses do not. Second, LDG contains a wealth of fossils including leaves, seeds, and insect nests, none of which would be expected to survive the heat and shock of the classic explanations.

When LDG was created, the area probably looked much like the Kelso Dunes area of Arizona above. Most of the surface was bare blown sand, with sparse vegetation and some exposed sandstone and quartz. My authority for this description is in my samples of LDG in the following report, which primarily show flash-frozen sand dunes and casts of seeds, twigs and leaves.

LDG is found in a roughly oval area ("strewn field") measuring between 2,000 and 6,000 square kilometers, running generally north from a plateau between Egypt and Libya. The field is about 130 km north to south and 50 km east to west. The entire deposit of LDG is on the Egyptian side of the border, and no Libyan Desert Glass has actually been found in Libya. This area was traditionally called the Libyan Desert, hence the name. I have no idea where my seller's material came from within that field.

The total current quantity of LDG has been estimated at 1,400 metric tons, and the original quantity has been estimated at perhaps 10,000 times that, or 14,000,000 metric tons. That would be a glass cube about 180 meters or 600 feet on each side. If the affected landscape were liquefied six inches deep, it would cover 10,000 acres, 15 square miles or 40 square kilometers.

The Sahara has been in its current arid state for only the last 7,000 years. The above image is a reconstruction during its most recent wet period. The prior more arid image and the one above may be taken as views of the various repeating stages during and since the creation of LDG. In this image the LDG current strewn field is shown as a red ellipse just below the center.

When the LDG was created about thirty million years ago this region was in an earlier arid period. The area which would become today's LDG field was about 400 meters higher than the current level, and whatever event created LDG took place on that higher surface. This was just north of the Gilf Khebir Plateau, visible in the above map below the red ellipse. The northern eroded slopes of the plateau may constitute the basement remnant of that higher elevation.

The exact date for LDG creation is uncertain, with an uncertainty range of about three million years. This is just before the start of movement in the East African Rift System. The uplifting of the Gilf Khebir Plateau was a precursor to the start of EARS movement. It's conceivable that the LDG was formed, the plateau was then uplifted, and erosion followed. The sequence seems unimportant.

In the course of the LDG formative event, the minerals varied by site. In some the top layer of loose sand appear to have melted to a crust. Elsewhere some thickness of sandstone and quartz deposits were fused. The liquefaction was extreme in some parts and may have solidified slowly, but there was no one recipe for the whole area. At the fringes the effect was intense but short-lived, the liquefied layer was thin and it solidified quickly. Farther out the sand barely fused, nearly retaining its individual and highly visible grain structure.

After this event, the area continued its cycle of wet and dry periods. The LDG had liquefied and solidified on the surface, and this glass eroded and broke up over time. During wetter periods streams formed, LDG washed into those streams, and that which didn't wear down to sand collected in the stream beds as heavier gravel and rock. In dry periods the land was worn down by wind and wind-driven sand, and the old stream banks wore away along with the land.

The beds resisted erosion because their accumulated gravel formed a windbreak, so each such remnant bed became a low ridge, slowly eroding toward its sides. With wetter times these ridges developed gullies, the new streams carried the ridge-top gravels off to the sides, and collected those gravels at their beds, and the cycle repeated. In this way about 400 meters of elevation was removed in 30 million years, leaving the remaining LDG scattered over a much broader area than the original formation.

Samples from this field vary widely in their histories. Whether a sample is buried or exposed can be measured by the effect of cosmic rays on oxygen and silicon in the piece. Slow etching by alkalis or weak acids leaves characteristic pitting when buried in damp environments, while abrasion by wind-blown sand can distinguish pieces that are exposed. Samples which have been tumbled in water show classic river cobble rounding. Samples of LDG show all of these, some of them showing multiple environments. This points to major redistributions and overturning of the material. LDG has been retrieved from exploratory pits down to about a meter depth, so this contrasting exposure is continuing.

My sample set is too small for meaningful statistics, and the provenance of any piece is a total mystery. It could have come from anywhere in the strewn field. Its interval sequence and duration of exposure or burial, of river tumbling or erosion by blown sand, are purely guesswork.

Weathering

There seem to be five weathering modes in play with LDG: Fracturing, Tumbling in water, Etching or corrosion by chemical or biological agents, Abrasion by wind-blown sand, and Devitrification.

Any piece of LDG was fractured. The largest piece on record, and large pieces available for sale, show where other pieces were broken off. Initial fractures were probably from temperature changes, and from the crust break-up as rains washed supporting earth out from underneath. Fractures can give us some useful information in two ways. They allow us to date some of the other weathering features, and they show human handling. Two of my pieces appear to be debris from knapping, and presence of other weathering gives some idea when that knapping might have happened.

Two fractured LDG pieces of about 6 kg each

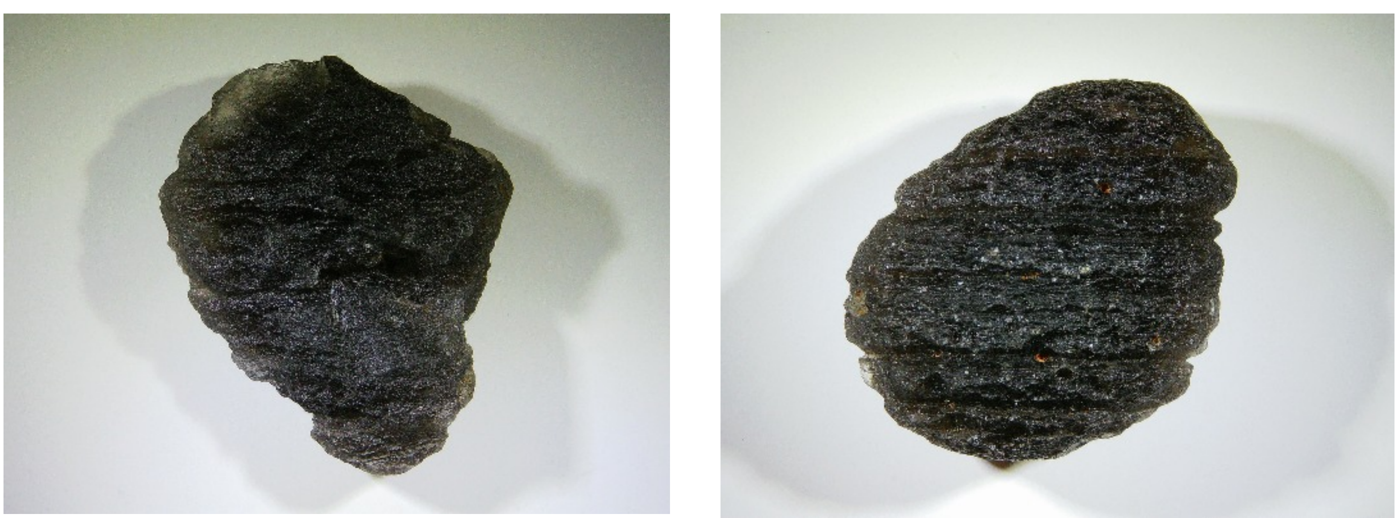
The primary dispersal mechanism for LDG was rolling down wadi bottoms, branching out from the south and moving mostly north and scattering to both sides. The entire field is about 130 km north to south, and the largest pieces are at the south end. I don't know the location of the 800 kg mass, but it must be very close to where it was formed. We might (for this conversation) take 15% of the distance from the southern extreme as the initial site, and consider pieces at the northern equivalent, 15% short of the northern extreme. Pieces at that northern locus traveled for about 90 km along wadi bottoms as the crow flies, so to speak, and perhaps 150 km following the fish route. So typical LDG pieces in the northern part of the strewn field traveled about 90 miles bouncing on other rocks during wet intervals.

River tumbling breaks off protuberances and rounds off rocks, and rounded rocks slowly wear down in overall size. The mass loss is not easily quantifiable due to the many variables. River tumbling is an excellent way to probe for weaknesses in rocks; if there's a flaw, a few million random whacks will find it. River cobbles are desirable as primitive hammers since all the weaknesses have already been found. This is useful for evaluating LDG, since breaking at weak points tells us something about the formative event for pieces that have been tumbled.

Glass is also subject to chemical attack by alkalis, a few acids, and water. An alkaline environment directly dissolves a glass surface, steadily consuming it as long as the alkaline chemistry persists. Acids are less destructive, but do form holes in the surface and introduce avenues for further erosion. Glass also degrades by materials adhering to it and pulling away. All of these are in play during wet periods, and leave characteristic pitting of glass surfaces. This increases the surface area, making it yet more vulnerable. Finally, pits may be the relics of gas bubbles formed when the object was molten, which were opened to the outside after a period of weathering.

The resulting pitted surface is typical of impact ejecta, tektites and obsidian. Small pits expand and the surface eventually is dominated by a few large cavities. In addition, the corrosion preferentially erodes softer layers, picking out internal structure, if any. The corrosive effect tends to create sharp edges, in the same way that one can sharpen a file by leaving it to rust a bit. The sharp edges are the first to go if the item is tumbled in water. So the sharpness of the edges in an eroded object gives an indication of what has happened most recently, as tumbling and chemicals compete to destroy the piece.

Progression of Natural Glass Pitting in Moldavite, LDG and LDG



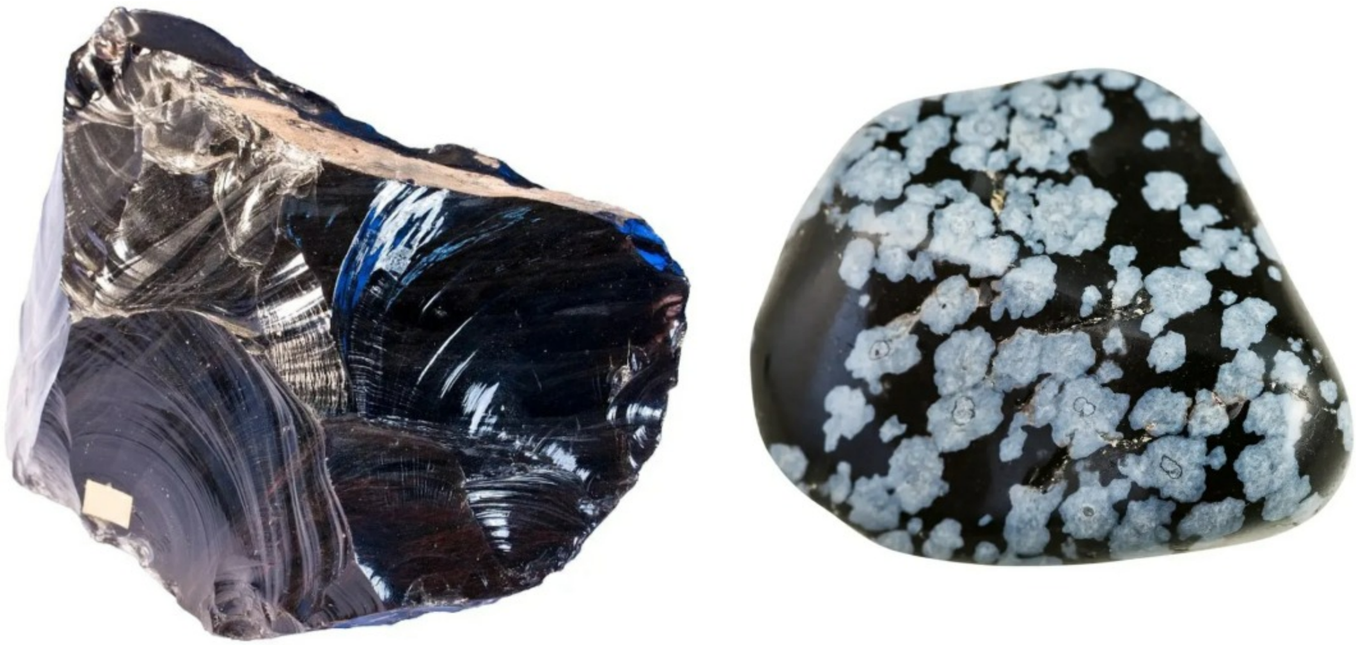
Pitting and layer-etching in Chinese natural glass

Abrasion by wind-blown sand is the primary weathering agent in dry intervals. Abrasion in water tends to round down the whole piece, as well as smoothing small details. Sand carried in water has to flow along the surface of any rock it hits; it cannot strike the surface directly. It can't do anything except smooth the surface, subject to eddies and swirls. But sand blown by the wind can hit the rock's surface at any angle from head-on to glancing. So wind-blown sand tends to exploit differences in rock hardness from layer to layer, and creates grooves or pits accordingly.

Sandblasting can't pick out any detail finer than the average grit being used. Blasting by natural sand and grit can pick out grooves, but any groove being excavated by smaller grit is going to be rounded off by the full-size grains hitting the high points. So natural sandblasting will be good at picking out grooves down to the size of a couple grains, but no smaller.

While not normally classed as weathering, devitrification may also have changed LDG over time. Glass is a very thick fluid, not quite a solid, whose molecules flow imperceptibly slowly. Devitrification ("devit") is the collapse of an amorphous glass into crystalline form, as individual molecules fit themselves into an adjacent lattice, slowly growing crystals throughout the body. As each molecule attaches to a lattice, it drops into a more stable harder state, and presents a new extension of the lattice to the next molecules in turn. It also changes the optical properties where the crystal is forming.

Where the optical qualities are not critical, internal devit may escape notice entirely. As a problem, devit is primarily seen on the surface, giving rise to a cloudy appearance as random surface crystals scatter light. This can happen as a piece ages, or during initial creation. The problem is well known in glass production, and is typically addressed by manufacturing changes. A surface marred by devit may be cured by having a fresh layer of glass fused to its surface, burying the crystals.



Obsidian Before and After Devitrification Begins

Devit typically starts at embedded impurities that act as seeds for crystals. Natural glasses have no shortage of impurities, and devit is commonly seen in obsidian, often destroying obsidian completely over about twenty million years. The devit process is entirely random; crystals grow from their seed point in any direction, and crystals absorb unlatticed molecules until they collide with the crystal next door.

I sketched two hypotheses that could create cryptic structure in dune glass, and one of these results in sequences of sand grains aligned. Their lattices, or what's left of them, are potential seeds for crystal growth. Where the LDG sets up slowly enough, these may grow in the hardening glass as silica molecules fit themselves into lattices, creating either healthy crystals with few discontinuities, or threads of roughly aligned lattices with many discontinuities. Competition with adjacent crystals for unattached molecules means neither of these situations gives rise to clear and unobstructed facets, so the difference would be apparent only using lab gear beyond my means.

Alternatively, these threads may be frozen in glass with only isolated lattices remaining for some or most of the sand grains. These lattices then become seeds for devit, in a process that differs from typical devit in two key ways. First, the crystal seeds are not random impurities but organized (though minuscule) lattices, so the piece is predisposed to kick off turbo-charged devit immediately. Second, the lattices are aligned in ranks and files, creating in effect skeletons for bundles of much longer parallel crystals than simple seeds could grow. Crystals are not constrained to grow in a given direction; they display directionality because their growing boundary first encounters a compatible crystal to bond with next to them in the thread.

This raises the possibility that the apparent structure seen today on the LDG surface might not be an immediate product of slow hardening, but could instead grow over time from threads of seeds as orchestrated devit. While a given etched LDG surface shows apparent structure today, it might have shown little of that ten or twenty million years earlier, before it ripened.

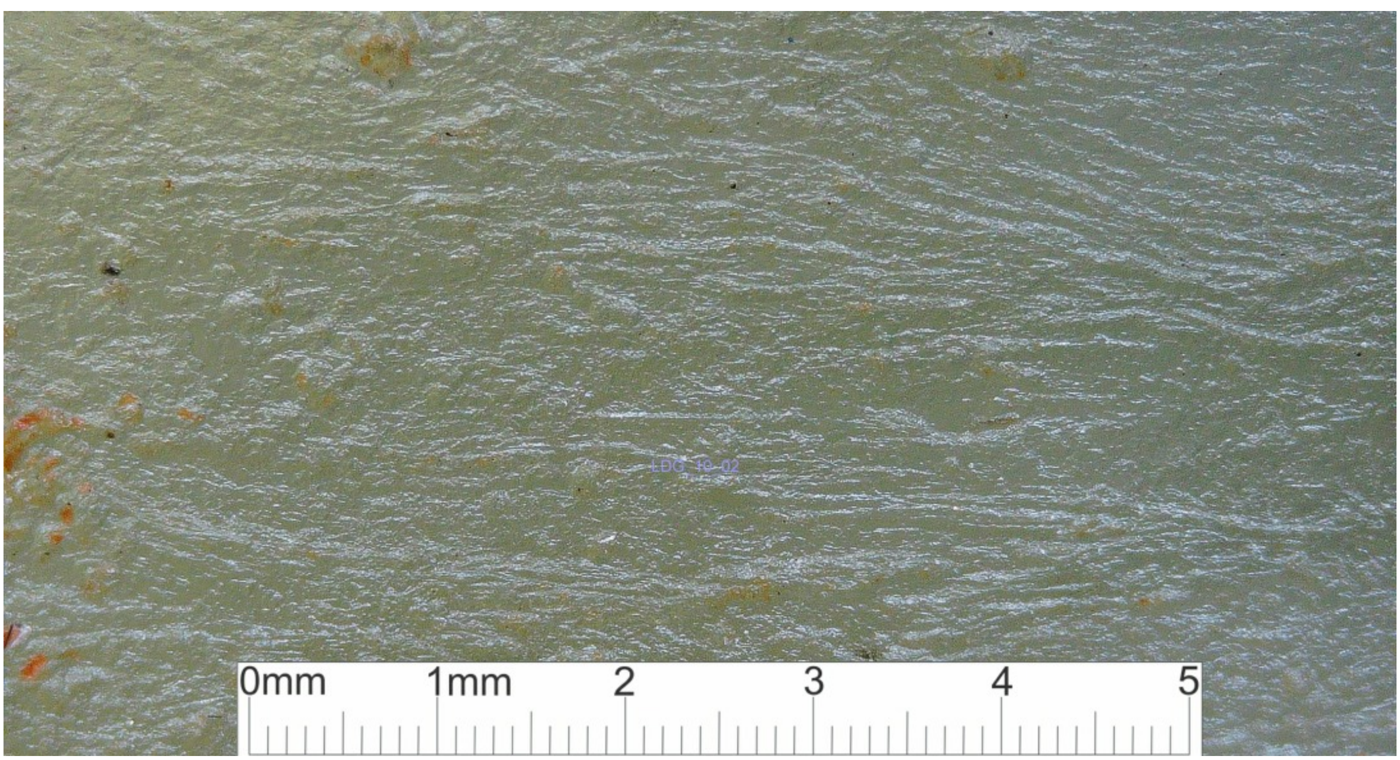
Evidence

I aim to demonstrate that a phenomenon of blowing sand was captured by a radiation event. I happened to find its footprint in Libyan Desert Glass, but it might have happened anywhere. If I'm correct, the blowing-sand phenomenon happens everywhere all the time. The radiation event is considerably more elusive. I first discuss evidence for the blowing-sand phenomenon, and then evidence for the radiation event.

Like a million-year-old human footprint in dried mud, it is enough to prove that sand-chaining happened once. It is not required to show that every dried riverbed has million-year-old footprints. To establish that threadlike crystals are found in LDG, I need to demonstrate that they appear, and there is no other plausible explanation for the manifestation. But not all LDG will have them. The formative event covers a spectrum from complete liquefaction and amorphous glass all the way to barely adhering grains like sticky rice. In a segment of that spectrum, the Goldilocks zone where conditions were just right, there are threadlike crystals, fossilized breezes.

They apparently have eluded identification because the classic methods of recognition aren't available. The crystals may appear on the surface as worm-like shapes; there are no recognizable facets large enough to command attention. They don't look crystalline, and have been interpreted as products of chemical action.

X-ray crystallography is not available. It requires a discrete crystal ideally about a millimeter on a side. If my thesis is valid, a cubic millimeter may contain a hundred of these lattices; probed by X-rays, this will produce only noise. Other tests such as infrared analysis may disclose that there are crystals, but the material must be crushed to prepare for the test, and threads don't survive the preparation.



Exposed Crystal Threads of LDG

The best technical proof of the crystals will be from thin slices viewed in polarized light. As I'll demonstrate, LDG tends to fracture along planes defined by these crystal bundles. We can describe what a good candidate sample would be. Any piece with one or more faces showing parallel external striations is likely. And any sample shaped roughly like a chandelier prism is another. The crystal bundles not only guide the fractures, they also strengthen the rock. So a piece with edges that are more or less parallel, and sides more or less flat, and several times longer than wide, is a prime candidate to probe further.

The next best technical evidence will be from Schlieren photography. The density difference between the amorphous and crystalline parts of a sample will show as distortions to light passing through. LDG which was liquefied in place and undisturbed should show parallel schlieren. I will show a piece that apparently flowed in a molten state, with my questions about the effect on crystals. Schlieren photography of such a specimen should show a corresponding tangle of smears.

I call these "technical" proofs because they require equipment I don't have. But the visible striations by themselves can provide three bases for concluding that these crystals are real. Each of these also suggests how my hypothesis can be falsified.

First, the orientation of crystal bundles will be consistent. Any face might show no striations, having been smoothed by water or wind-blown sand, or etched into pits. But faces that show the orientation of striations will not conflict. If the crystals resemble a sheaf of spaghetti, then they will look like that same bundle from every vantage point that exposes the bundle to view.

A promising prism-shaped test candidate

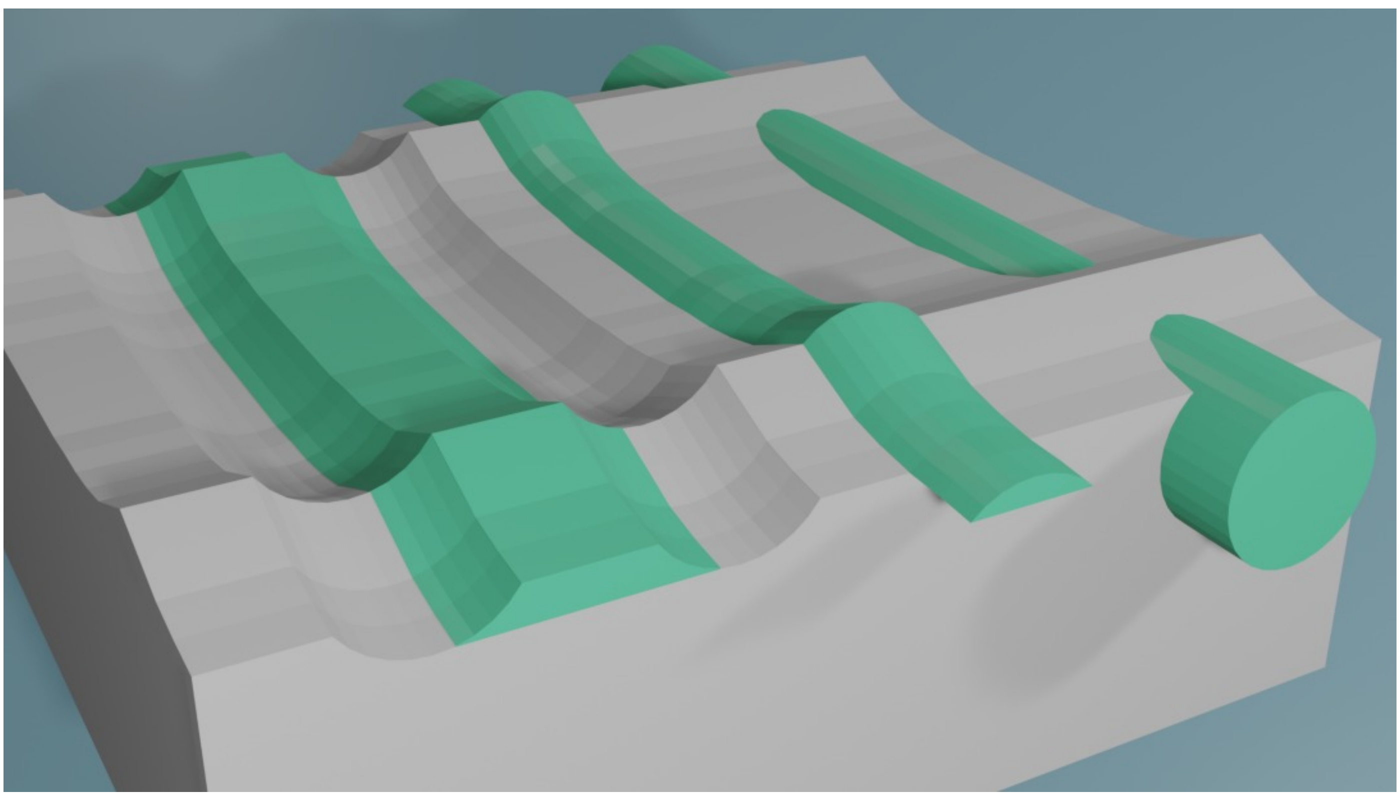
Second, threads will not have progressive divisions. As flow products they may waver, and may split and perhaps rejoin along the same general axis like a stream splitting around rocks in rapids. But they will not form the equivalent of a delta or bush, dividing like trunks into major branches, minor branches, sprigs and then twigs.

Third, threads will not change vector to wrap around edges or cusps. When threads come to an edge, the noodles will not bend to follow around the corner.

Finding any of these three invalidates my thesis.

The phenomenon often called “worms” on LDG specimens are what I am here identifying as crystals. In the common view, these are products of chemical processes, either etching the surface as in the left instance below, or perhaps accreting material as in the center instance. If either of those were in play, the striations would follow contours of the sample, unless of course the sample were fractured subsequent to the creation of the striation. But what actually is shown in LDG is like the right instance below. Crystals follow lines that are approximately straight, and are intermittently exposed by variations in surface contour.

The consensus holds that LDG is amorphous, and some medium involved in engraving or accretion applies detail to the body. I suggest the LDG is instead filled with detail as parallel crystal threads, and this structure is revealed by an etching process that is wholly homogenous like paint remover. The detail is in the LDG, not in the etching medium.



Evidence for the proposed radiation event is circumstantial. I have no data indicating LDG is more or less radioactive than other specimens from the area, for instance. In part, the evidence for radiation is the evidence that the high-impact scenarios of a meteorite impact or air-burst are implausible. Thus evidence for the radiation event includes it being the last conjecture standing.

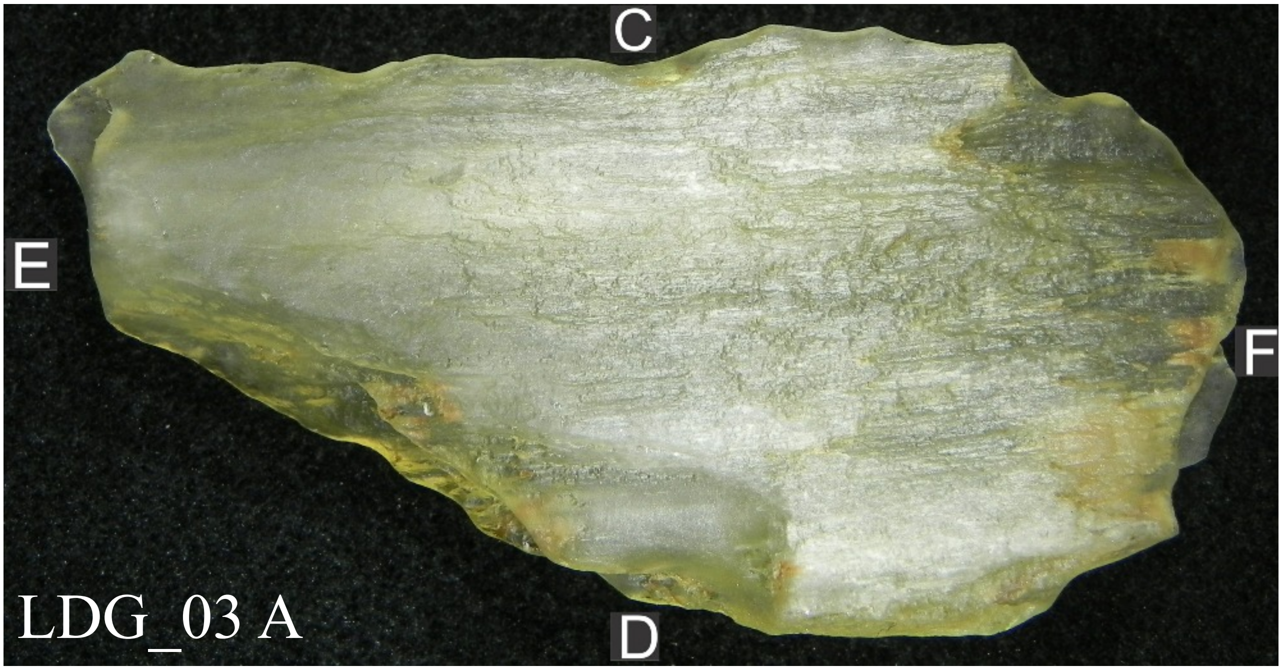
There are four lines of evidence that LDG was low-impact and low-temperature. First is the presence of silica lattices that can be dated to the formative event, as opposed to crystals that developed through devit. That is, the ‘worms’ mentioned above are not only evidence for the blowing-sand phenomenon, they are evidence that the sand did not melt.

Second is the presence of actual unmelted sand grains that are visible in the LDG mass. These are not the apparent threads of chained grains, but distinct bodies, partly rounded and cuboid, made visible by air bubble contours captured in the glass.

Third is the presence of fragile fossils that can not plausibly survive a high-pressure shock sufficient to melt silica. These include leaves whose thickness can be measured in their casts, and insect nests and tunnels that are not flattened by a shock.

Fourth is the evidence of extremely low viscosity in the fluid silica, lower than the viscosity of water, contrasting with the honey-like viscosity of molten glass. This is demonstrated by the ability of the liquid silica to wick into dry sand, into microscopic leaf surface features, and between plant membranes and leaves. This extreme fluidity is shown in toroidal vortices (bubble rings) with an overall size near a single millimeter and bubbles captured in mid-spin.

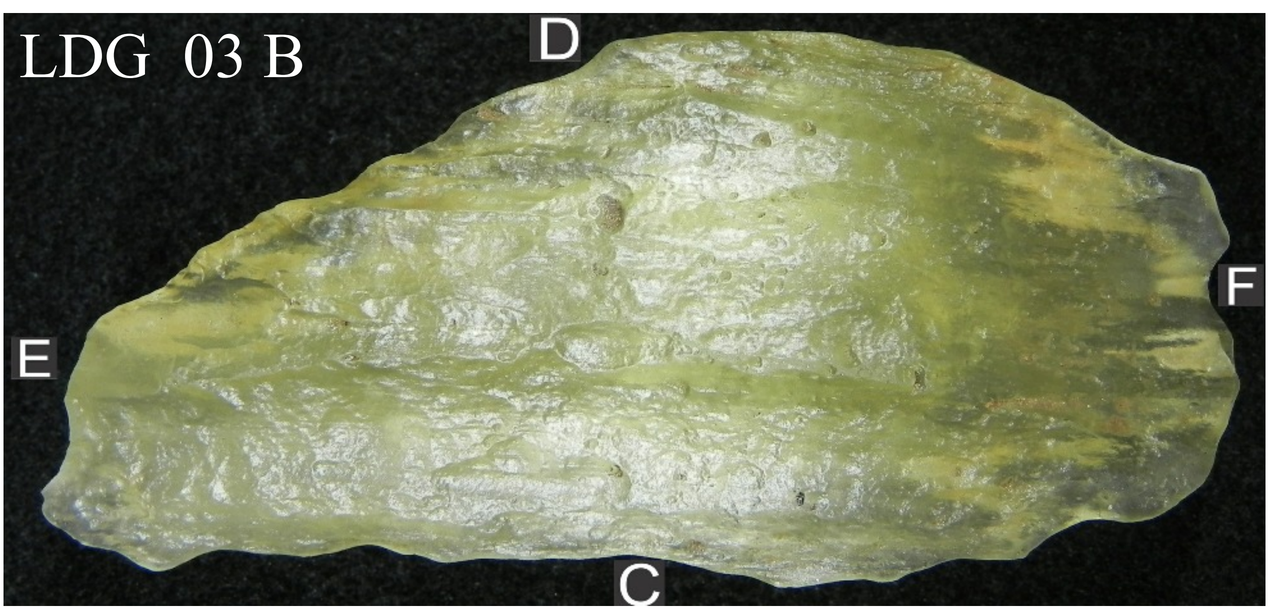
I don’t claim any of the specimens presented here are unique. These were easily collected and are no more than convenient examples which anyone should be able to duplicate. The following samples are simply a visual aid pointing a ready path to explore if one cares to look.

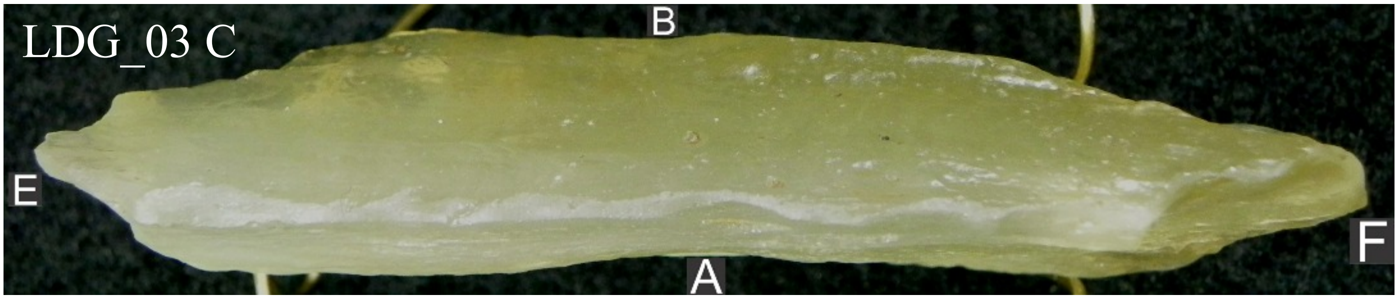


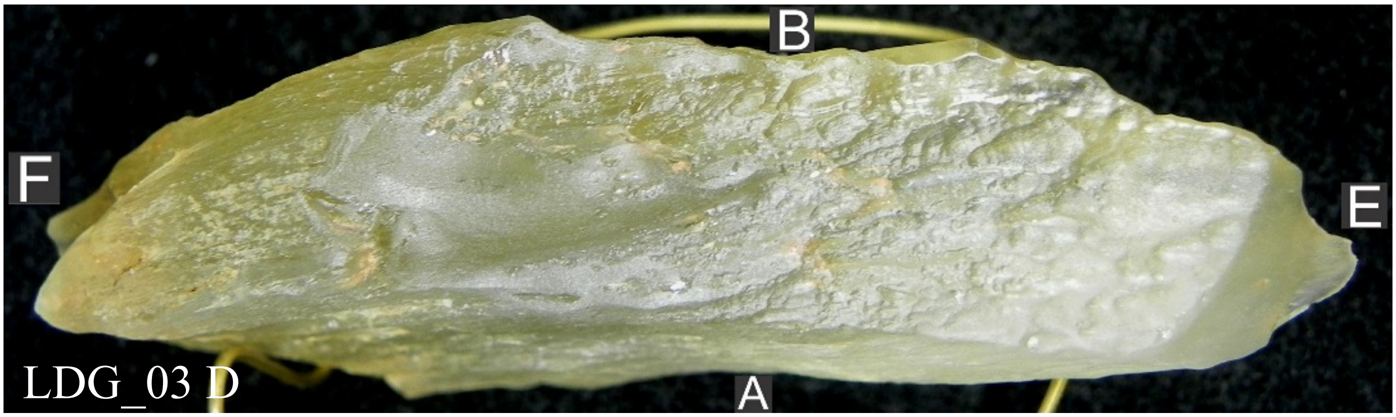
Sample 1 - LDG_03 - Apparent Threads

The first sample appears to illustrate both of the mechanisms I've proposed for building structure in LDG. Thread-like grain runs the length of the piece, and these threads seem to be laid down in layers. The overall impression of the texture is something like wood. The item also supports my thesis of a radiation event by showing a rapid fall-off of liquefaction effect.

Sample LDG_03 is 3.5 inches long and just over half an inch thick. It is quite flat, with two of the major sides coming together to make an edge on two aspects (C and F faces in the image above), and the rest has a short flat and skewed face (D and E in the image above). The A side shown above is generally flat and has striations on the whole surface. On the left above these are more subtle, and gives the impression that the surface is well aligned to the internal grain. The right side shows a cascading breakage as the piece becomes thinner starting about the middle and moving right. It looks like wood that's deteriorated or broken off corresponding to growth rings. The B face is convex and has no fine striations. A flute spans most of the lower face, and most of the surface is pitted.







As shown in images C and D above, the side A with striations is largely flat, and the pitted side B is a broad convex. The edge shown in C is rounded as if worn. Side D also shows fine striations, and the grain curves downward toward the left, roughly matching the curve of the convex side B.

The difference between the two faces A and B is striking. For any weathered item there is always a question whether the two sides were exposed to the same environment, particularly where sandblasting is involved. But where chemical etching seems to be in play, it’s likely that both sides were in the same chemistry.

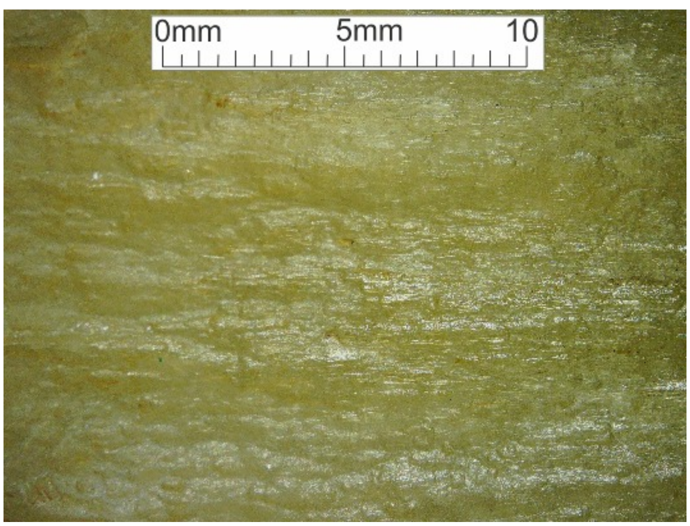
When natural glass is chemically etched, the pitted appearance is typical. Random weaknesses in molecular binding become openings for dissolving. Microscopic pits expand over time, larger ones overtaking and erasing smaller ones, continually weakening the dissolving agent by feeding it. In amorphous glass there is nothing to stop a pit from growing as the glass dissolves. But a crystal is relatively more robust, its atoms bonded to the lattice more tightly than to atoms beyond the lattice. So when a dissolving agent reaches the surface of a crystal it finds a more resistant structure, and spreads out to find weaker links, leaving behind exposed crystals.

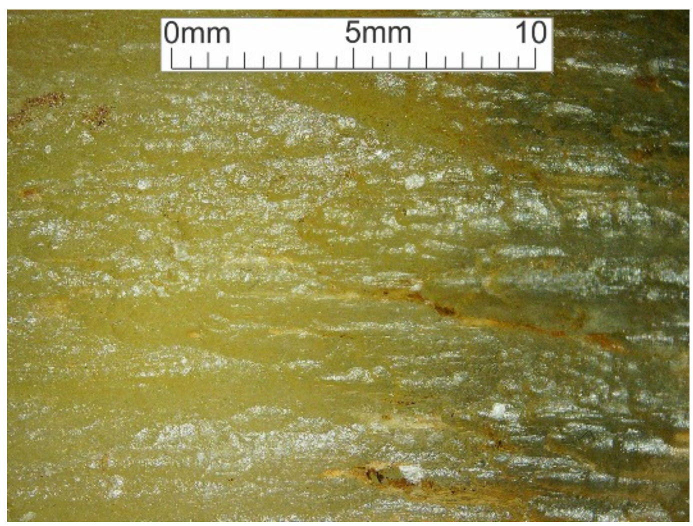
The left and right sides of the A surface are shown below. The left side surface seems to be congruent with the grain of the mostly buried crystals and is smoother. The right side shows the eroded-wood effect. Under greater magnification it appears to show individual crystals being eroded from the right, where they rose out of the surface, consuming them toward the left.

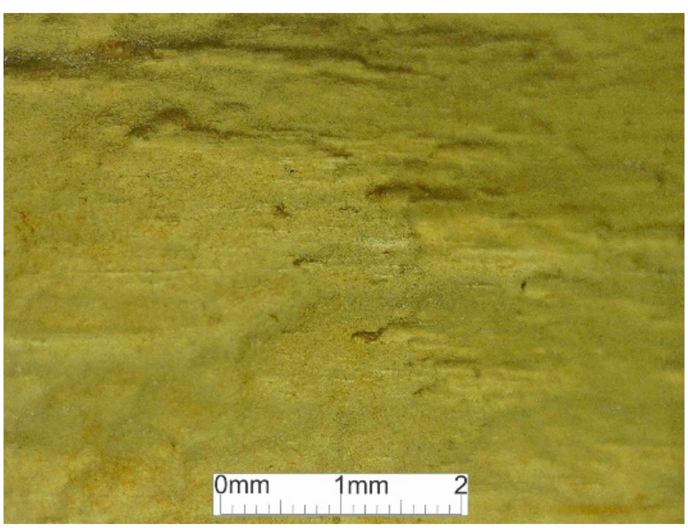
The appearance of individual crystals distinguishes my two conjectures. If no crystal threads were apparent from this angle, it could be explained as nothing more than dry varves, with sand and dust interleaved, and now peeling open like plywood. But individual crystals argues that this was laid down in threads of grains. The dust may form layers in conjunction with sheaves of crystals. It's a question of which seems to predominate.

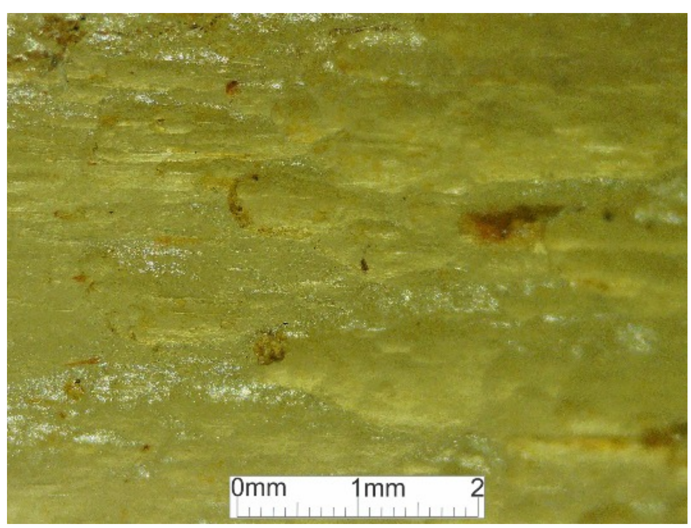
Evaluating this piece in the framework of my hypotheses suggests that the curved and pitted B surface was roughly the exposed surface during the heat event, and the flatter striated A surface was a half inch down in the ground. This is oversimplified, since both surfaces are what remain after an unknown amount of etching. We are looking at not the exposed surface, but a bit lower than what was exposed.

Again per my model, the upper (exposed) surface was entirely liquefied, and sand grains lost their lattice cores completely. Farther down, the lattices remained at least enough to either grow crystals as it set up, or seed the eventual devit crystal growth. Neither of these should obtain if sand liquefies entirely to amorphous glass. Fragments of lattices are unsurprising. The key feature is that they align in strings, and this can have come only from being organized that way in the loose sand.





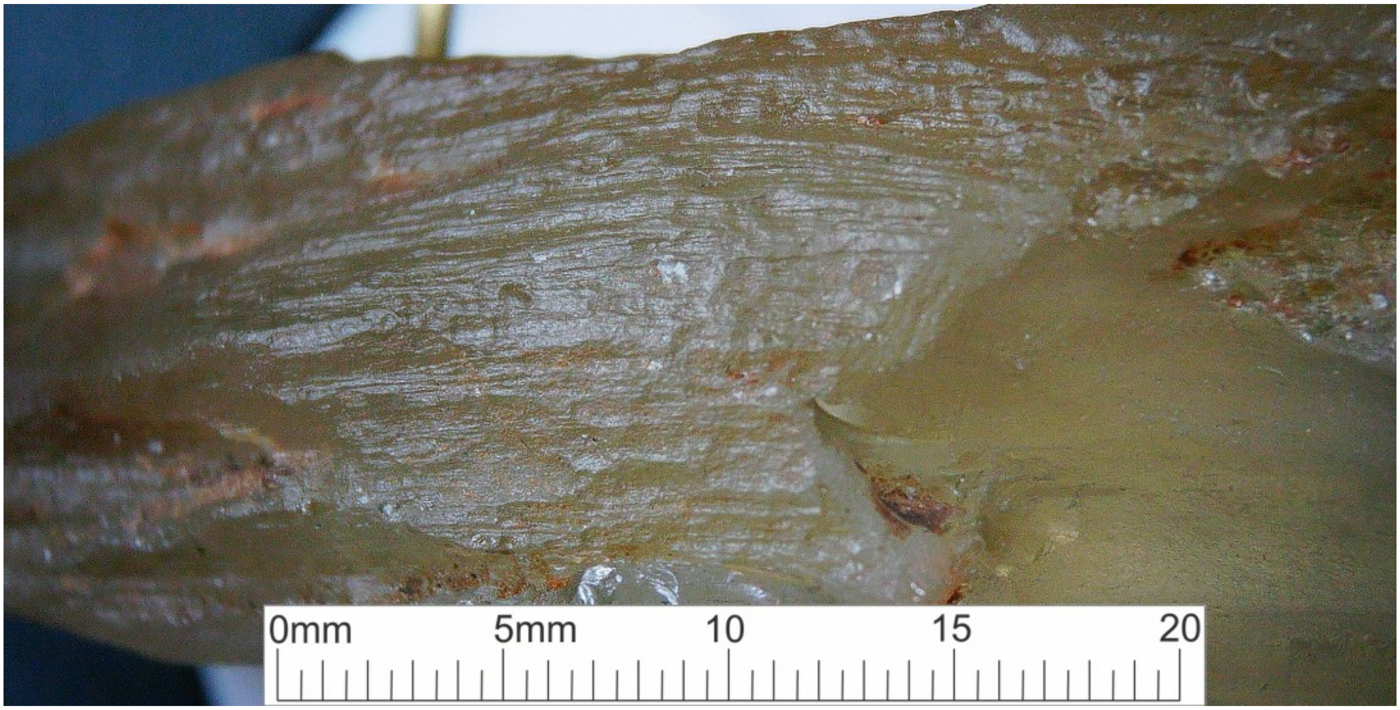




The cascading breakdown of layers is seen above from a more oblique angle. The smoother striations are on the left, and the piece thins down on the right.

These striations have been dismissed as an etching product of some biological agent, such as a lichen or fungus which features an extremely linear growth pattern. If the present sample surface were the product of such etching, it would follow the curve as the piece thins down toward the right. But what we see here are successive breaks, where striations end entirely while new striations are exposed beneath them and proceed to the right.

These lines are not details being engraved onto the sample by a linear external agent. They exhibit a structure within the sample being exposed by the fracturing and erosion of the surface.



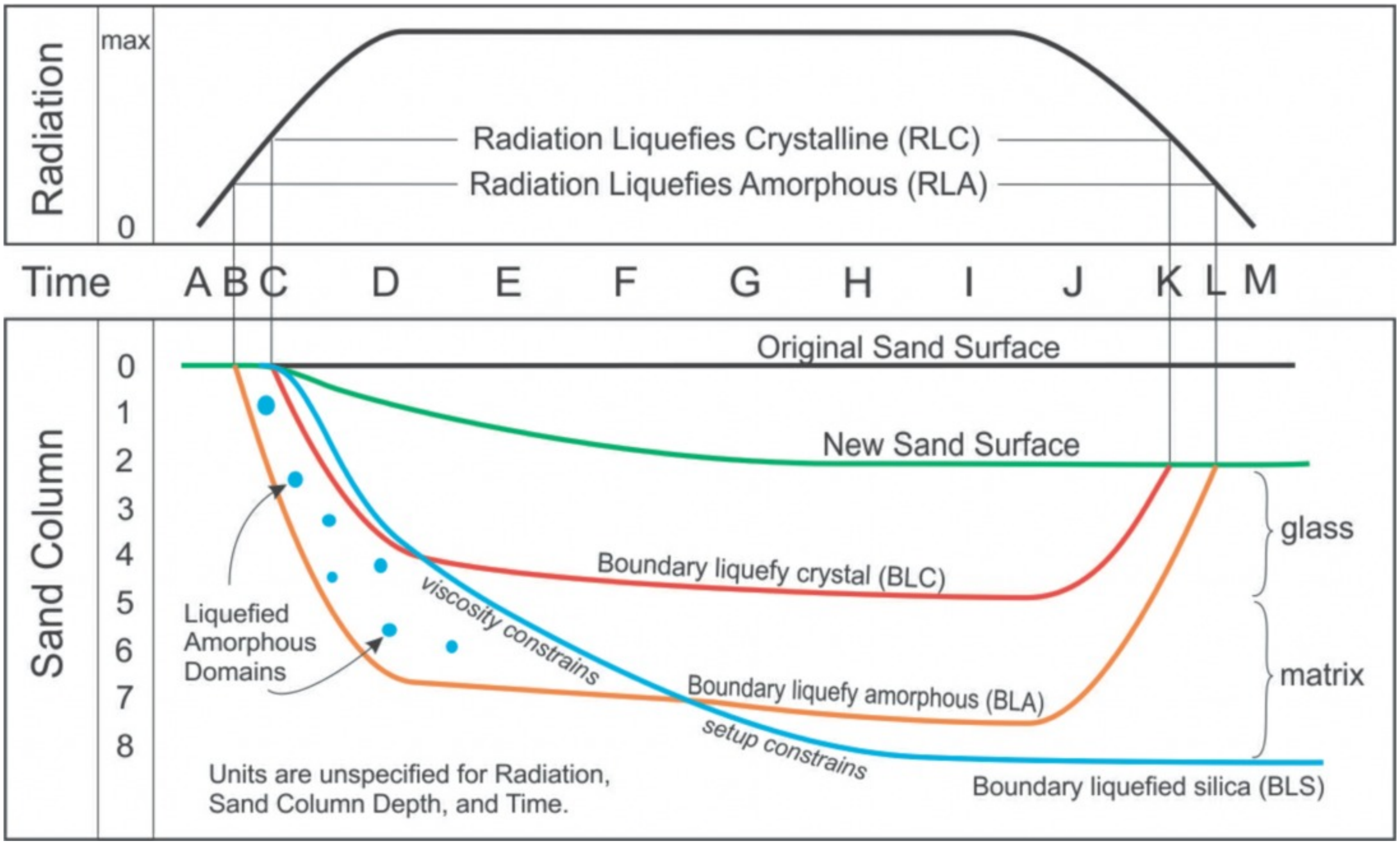
Another grained surface presents on side D above, which is at a right angle to side A. Side A seems to show layers, but within those layers the individual striations are clear. Side D shows no layering, just a thread-like appearance. Taken together, these two sides suggest that this sample is best described as threads of crystals following my second conjecture. In other words, if striations are found in two views that are at right-angles, then it looks like threads, and not layers seen edge-on.

Yet the plywood effect noted earlier clearly looks like layers. My thesis statement mentioned that the threads might lay down and finer fragments could settle more slowly on top, so that threads and layers could both be in play. This seems to be what has happened with this sample. Threads appear to be laid down a sheaf at a time.

The key feature in the above image is the curve of the layers which follow generally the curve of side B. We might characterize this piece as the crest of a sand ripple, and the threads show the sequence being laid down as the ripple grew. I'm not aware of another conceptual model for the curved striations.

The LDG formative event has been characterized as extremely hot, long-lasting, and slow-cooling. I suspect the "slow cooling" referenced in research papers alludes to these apparent crystals supposedly formed as the glass cooled. But the regular and parallel alignment of crystals argues that some lattices survived, and so the event could not have been both extremely hot and long-lasting for this sample. The contrast over a distance of half an inch suggests the heat event (in this item's location) was too brief for heat to equalize over that minimal depth.

Considered as a case of beta radiation instead of heat, this sample makes more sense. Alpha radiation can be stopped by a sheet of paper, gamma by many feet of earth. But beta radiation can be stopped by a few millimeters of material, depending on the energy of the radiation and characteristics of the target. As discussed earlier, beta radiation (electrons and positrons) can liquefy amorphous silica, and at high levels can liquefy crystalline silica.



Radiation and the Sand Column

This image illustrates the sequence of processes I propose for a radiation event. This is a schematic diagram, so there are no units implied for radiation intensity, depth of sand effects, or time. With time moving from left to right, I show the level of radiation increasing to a maximum over time, staying at that maximum for an interval, and then dropping. The rise and fall could be instantaneous, but the gradual rise and fall lets me better illustrate what I'm proposing.

When the radiation reaches the level that can liquefy amorphous silica, that effect penetrates into the sand until the sand mass attenuates the radiation below that level. The boundary of that effect is in orange. Within that boundary domains of amorphous silica will liquefy. If large enough they may drain downward but likely will soak into surrounding sand and remain in place.

As the radiation increases to the point that it can liquefy crystalline silica, the silica begins to flow downward. The liquefied grains fill the interstitial void, here shown as about a third of the loose sand volume. All grains above the red line turn liquid, and the blue line is the boundary of the resulting fluid. Since the fluid need only fill the interstices, the blue boundary encompasses a larger volume than the difference between the original and the new dune surface. I show a slight time lag between the arrival of the RLC radiation and the dissolution of the grains.

The sand flowing downward displaces interstitial air beneath it, except for that which is trapped as bubbles. Once crystalline silica is liquefied, it can be sustained in a liquid state by the lower RLA radiation within the orange boundary. So it will wick and flow downward, constrained only by its viscosity, soaking through the region above the orange line. This leaves a matrix of surviving grains bonded by the liquefied silica after it sets up. That matrix may contain my proposed threads, or just random grains.

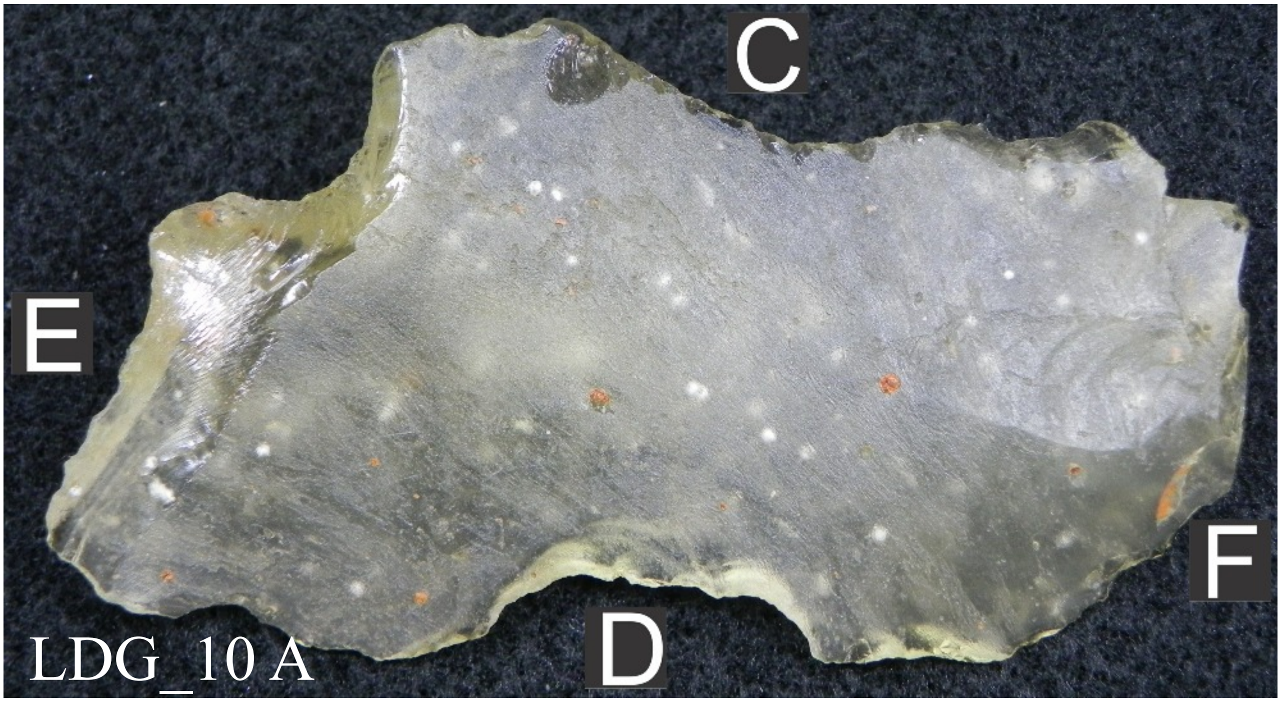
For the duration of the radiation, the dune surface collapses and sinks. The radiation penetration is attenuated by the mass of sand, but not by its thickness. So the collapsing surface does not expose additional sand under the red or orange curve, and the penetration is limited by the radiation level.

However, as the liquefied sand within the blue boundary flows down past the red and then the orange lines, this is reducing the sand mass above those lines, the radiation barrier reduces, so the red and orange boundaries incline downward over time.

The fluid silica may move downward past the point where the radiation can sustain it in a liquid state. Such a flow is constrained by the time it takes for the silica to set up when radiation halts. I can't estimate that setup time, just pointing it out.

This sketch is not intended to be exhaustive. The event may be highly variable over the site, so some parts may not have radiation intense enough to liquefy crystals, or it may be too brief to leave any traces. Radiation sufficient to liquefy amorphous silica may be insufficient to maintain the liquid state when the silica is presented with crystallization opportunities. In other words, when a bath of silica forms within the orange boundary containing the remaining crystals, those crystals may readily grow.

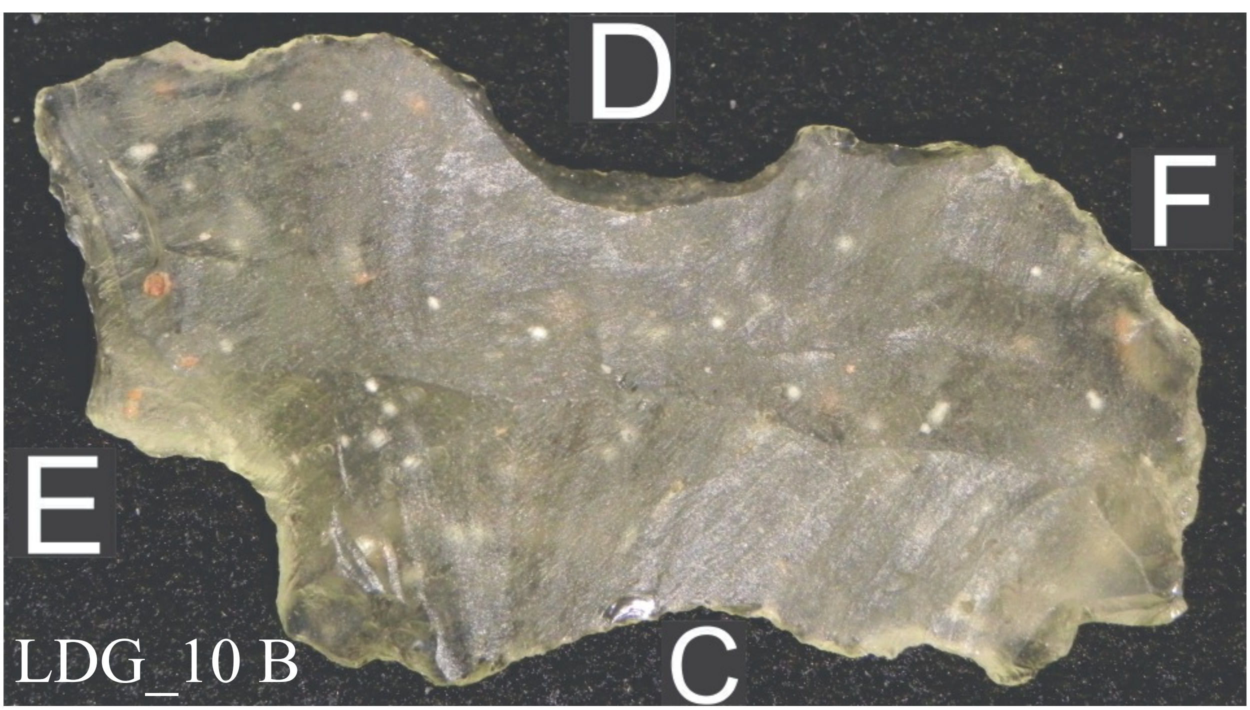
Returning to the subject sample, if there was a significant difference in effect over a distance of half an inch, we can presume the sand below this piece would have been affected even less. So this item may represent most of the fused depth at its location, and this may explain the thin profile. The largest reported piece was estimated at 1800 lbs, suggesting substantial thickness and corresponding formative action, perhaps including flow and pooling. So this piece was likely to be some distance from the center, without trying to estimate how large the field was or where in it this item formed.

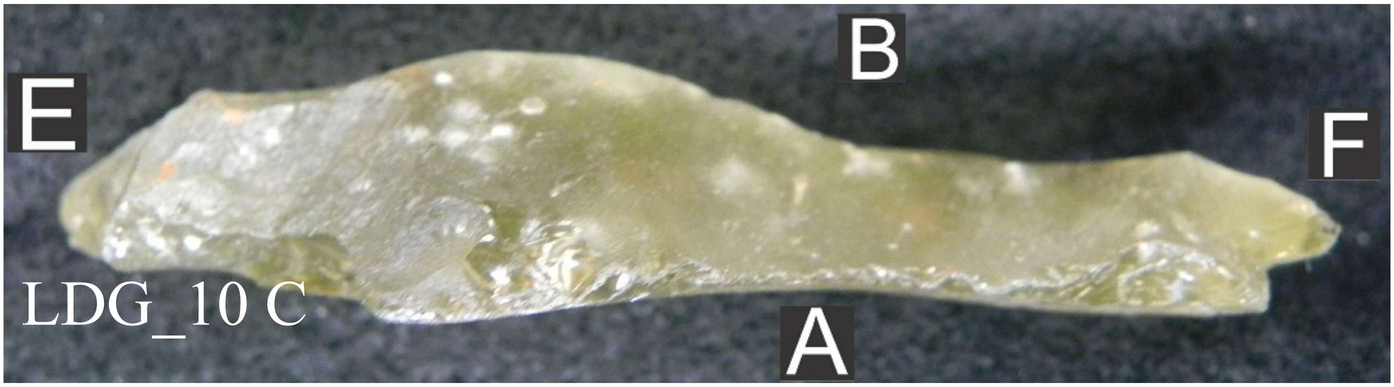


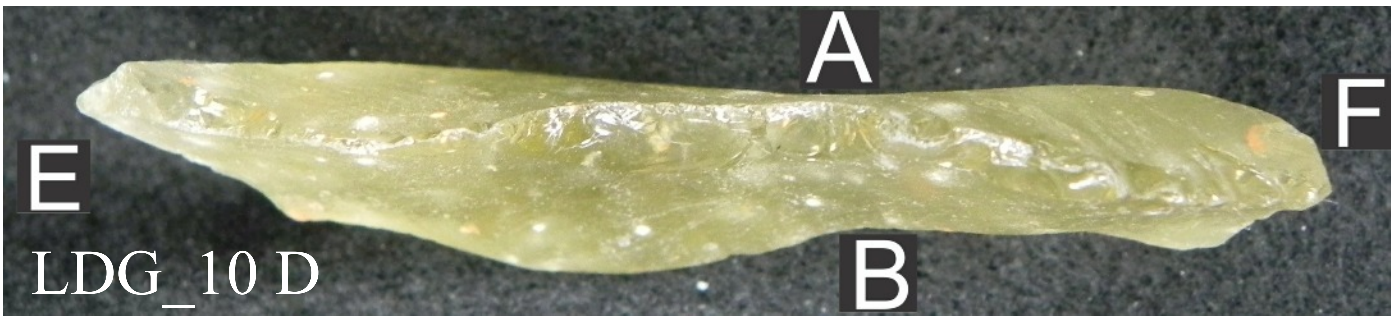
Sample 2 - LDG_10 - Knap Dissection

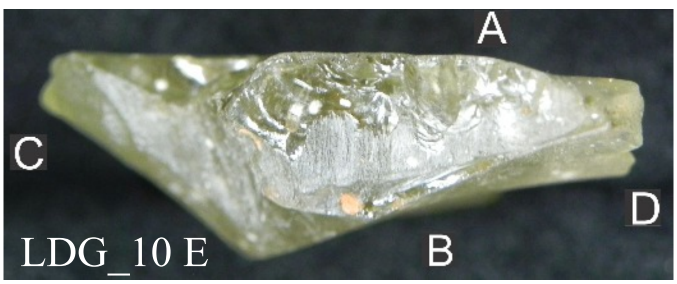
Earlier I proposed the sheaf-of-spaghetti-noodles metaphor. If my view is valid, then those noodles will agree no matter how the sample is cut apart. This piece shows what the crystal threads look like when a piece is faceted at different angles. The piece seems agnostic on the radiation argument.

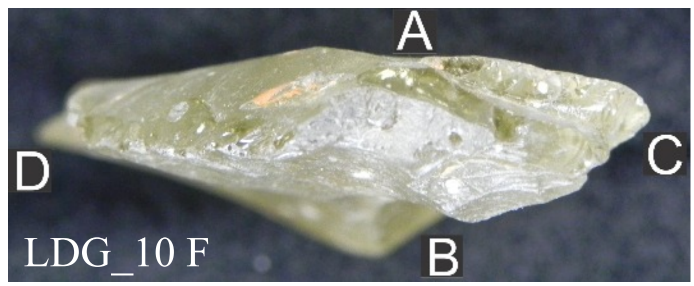
LDG_10 is a flat piece 3” by 1.5” that was shaped by knapping. It looks like a practice piece, with a short flute on the right end of the A side above, and extensive material removal on the B side below. There is no apparent plan leading to a point or scraper. Some of the chipped area is glossy, might be contemporaneous with its modern collection, and I don’t consider it of any historical importance. Most of the surfaces exposed by knapping appear to be etched and display the orientation of crystals. Even at this low magnifica-







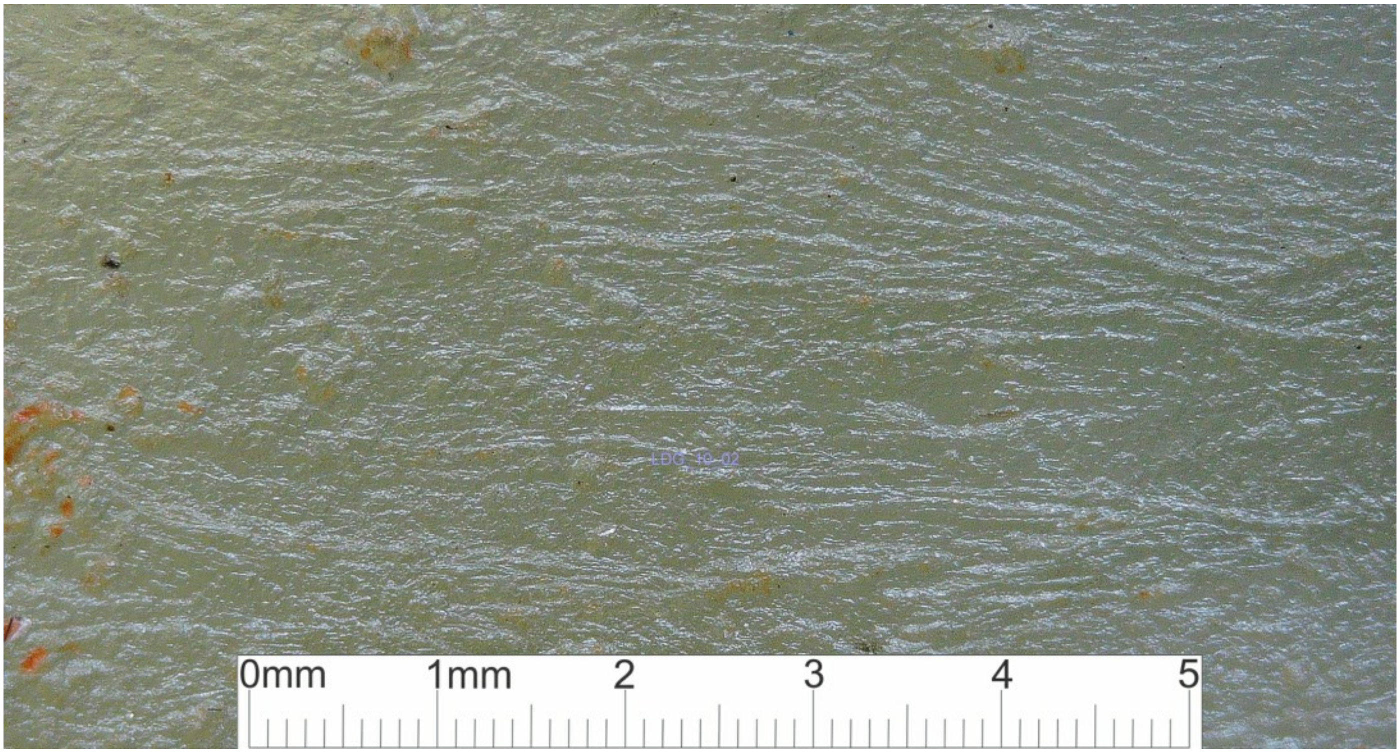




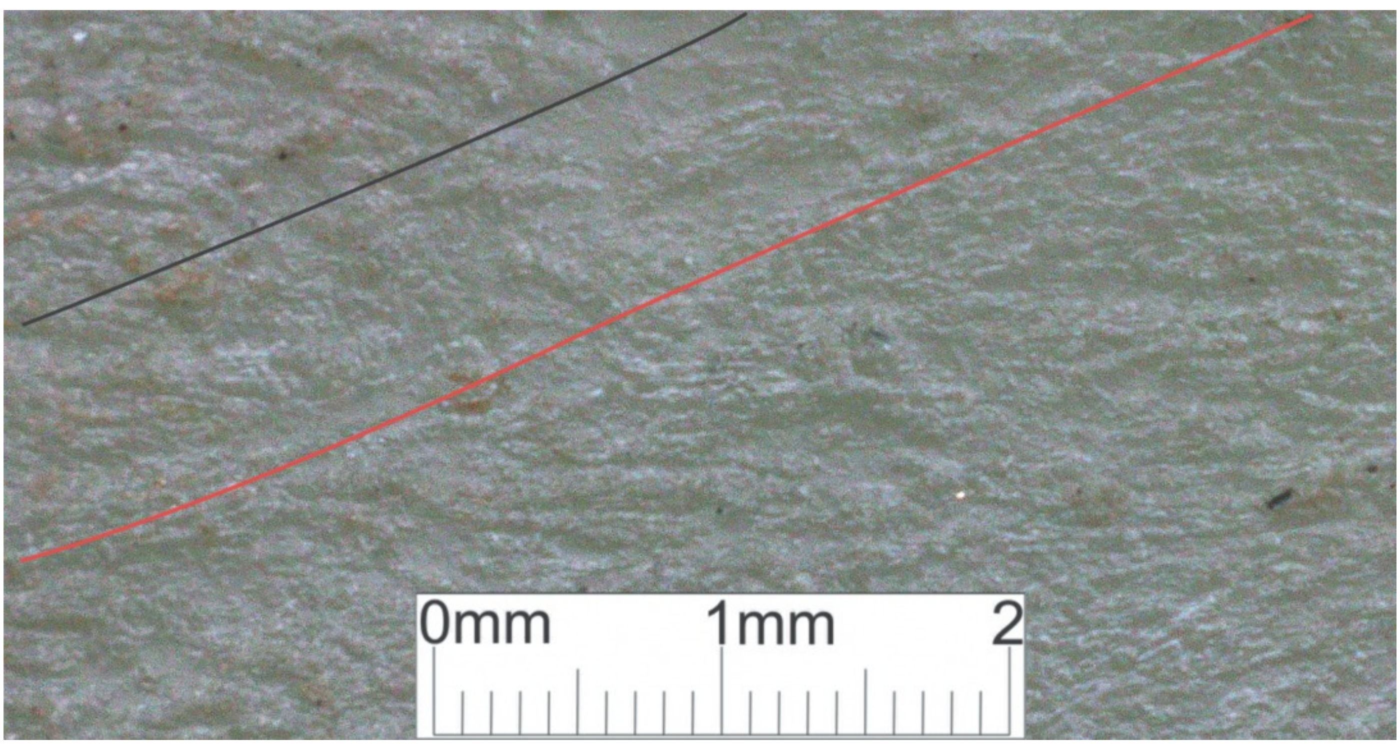
tion, the A side shows striations completely covering the surface in lines from upper left to lower right, and mirrored on the B side. There is a thin scattering of white spots through the item, likely cristobalite. This is a form of silica which typically forms at very high temperature, but also can form at low temperature over long time as a product of devitrification.

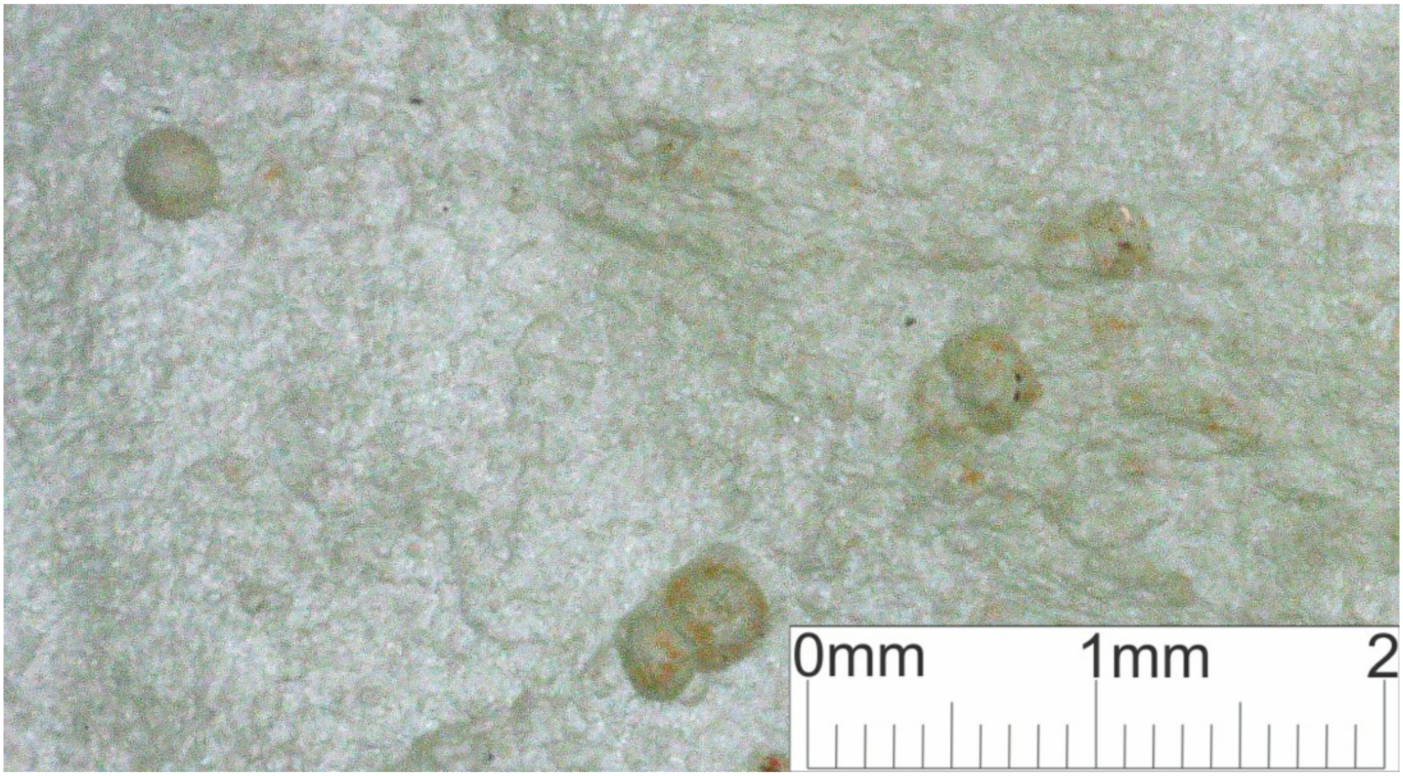
The A side is smoothly curved except for the single small flake removed, and gives the impression of being the natural surface before any knapping. It has low rises on the left and right, and a slight depression in the center. The uplift at the E end appears to be an increasing curve, with that end broken off in two large fractures.

The B side has two long conchoidal scars running the length of the piece, both visible in the preceding image. The piece plus something was probably flaked off a larger block, presumably to prep a core for multiple points. Then this piece was flaked off again, and later seemingly used for practice.



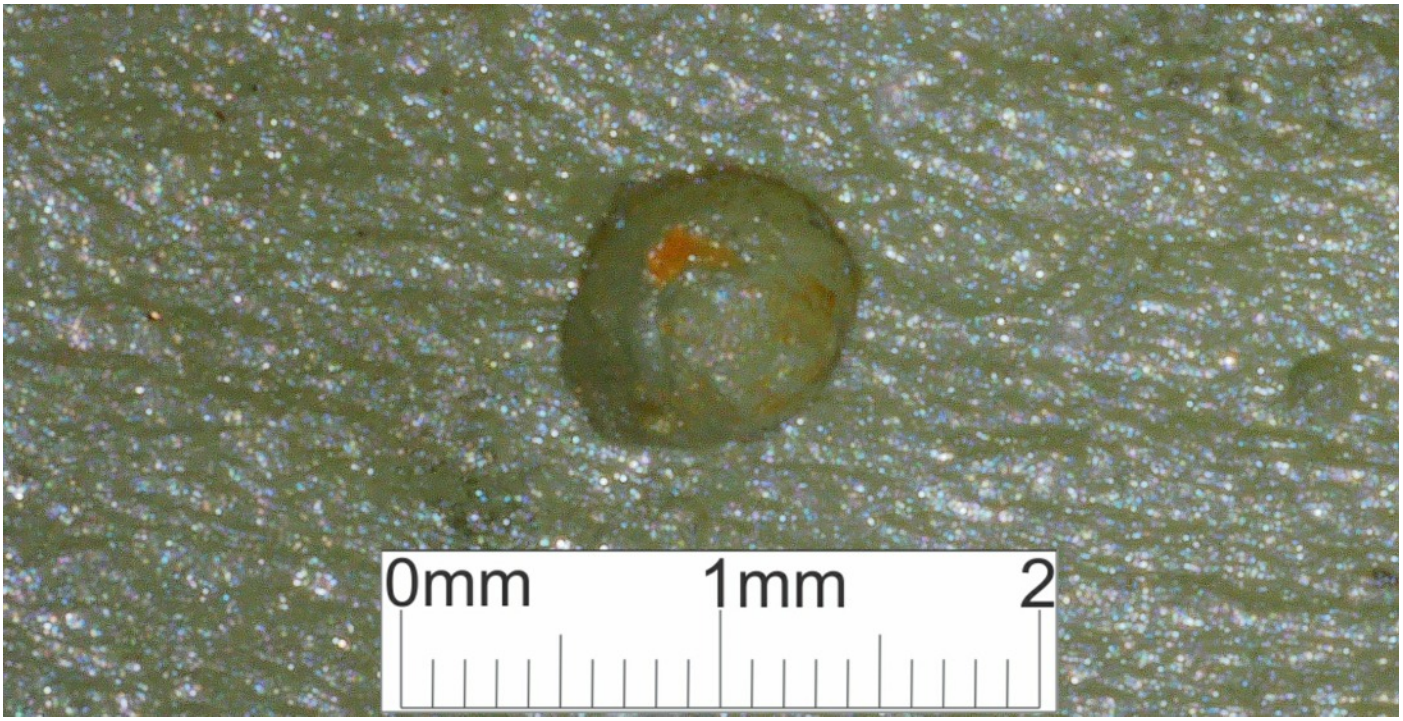
The entire A surface is covered with apparent threads, as above. They lie congruent to the surface, so they are remarkably long. Threads in the shallow A-side flute (below) are congruent on its central floor (top left above the black line). As the flute bottom curves up near the black line, the striations become chaotic up to the cusp (red line). Beyond the cusp (below the red line) they are again longer. This shows that the striations are not something that accreted or was engraved on the surface during weathering.





The A surface has many scattered pockmarks. Eroded pockets tend to have sloped sides and rounded edges. These pockmarks have straight sides and sharp edges. I suggest these are left by rounded bodies other than silica which have now been etched free. These appear to be cristobalite vacancies being freed over time as the surface erodes.

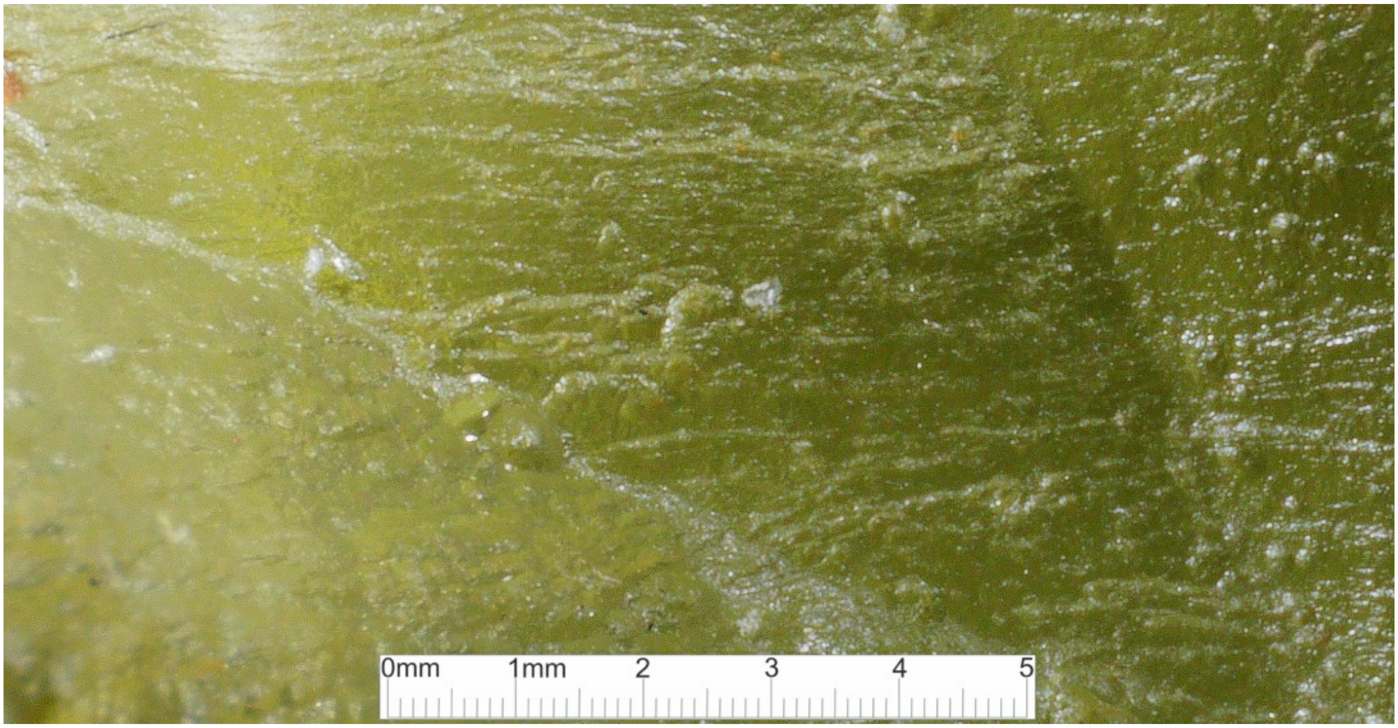
Below are two images of these white objects in the sample, viewed in a bath of Karo Syrup. There are some small bubbles in the syrup foreground. Karo Syrup has a refractive index approaching glass, it makes rough and uneven surfaces transparent without grinding and polishing, and I use it extensively in this project to see into specimens. I call it Super KaroVision.



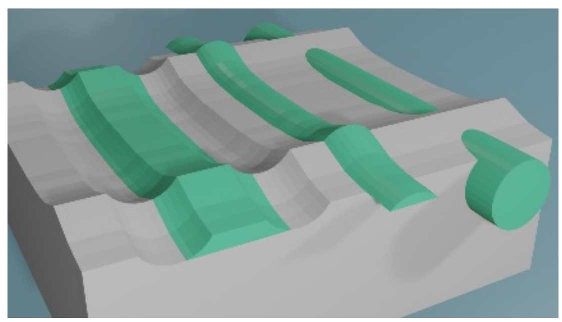
The image above shows a larger pockmark straddling a shallow trench running left and right, with a thread down the middle of the trench. Presumably this was another cristobalite that was freed by surface erosion.

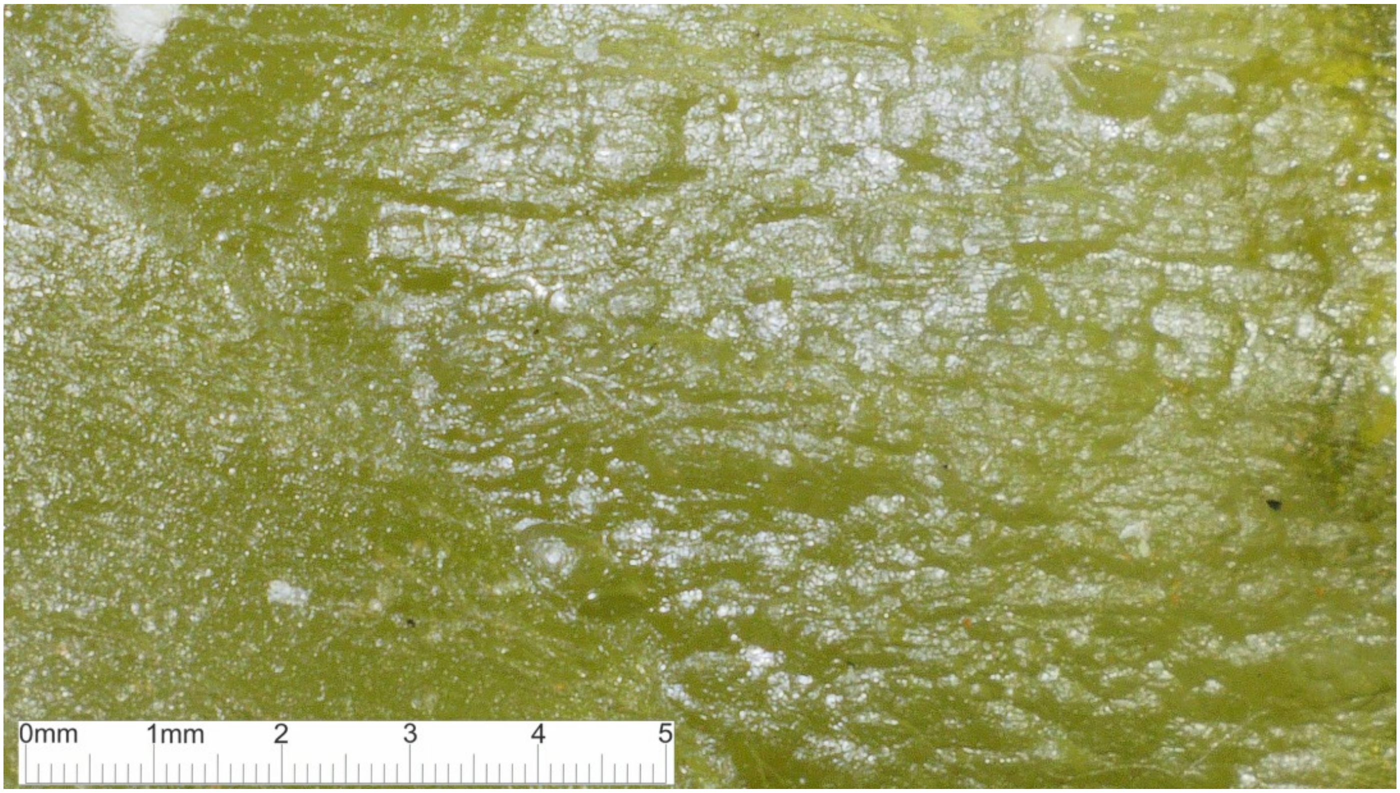
The surface threads have been dismissed as the product of some highly linear biological agent - a lichen perhaps - etching away the surface. Whatever that agent is, it must be fine enough to create the level of groove detail seen above. Yet if it exists it is also large enough to leap over the pockmark without missing its stride. There is no distortion or tentative probing of the grain as the purported growing plant encounters the hole, or perhaps grew up and around the cristobalite before it was freed, and the grooves on both sides align as if the obstruction were never there.

Following my model, the threads would have been deposited from one side to the other of this face in continuous fashion before the cristobalite formed. More sand would have been deposited over this surface. In the 30M years following the formative event, the cristobalite formed deep in the rock, to be eventually bared by abrasion and chemical erosion. I suggest this scenario has more explanatory value than some agent which etches detail into the surface.



The B side has a sharp central ridge left by the knapping, with flutes running partway down the ridge from either end. Both flutes have curved bottoms which are partly congruent with the apparent threads. The E end of the ridge (above) has steeper slopes. While the threads can be seen on the floor of the flute, they are harder to discern on the slopes outside the flute. The F end of the ridge (below) has a more shallow flute and additional knapping which makes that whole end more gradually contoured. The threads can be seen on the flute floor and outside it, obscured only at the cusps left by knapping.

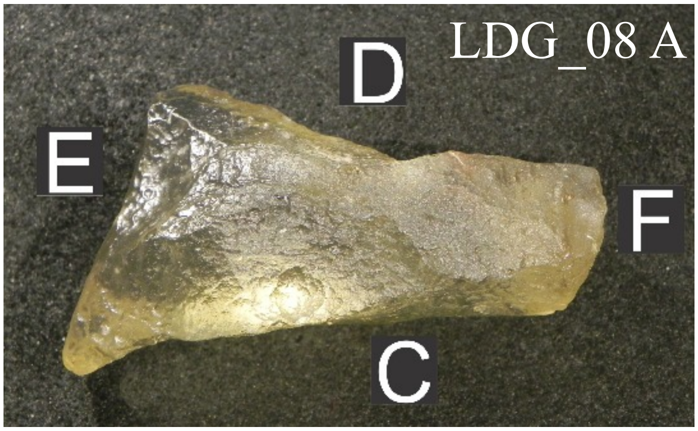


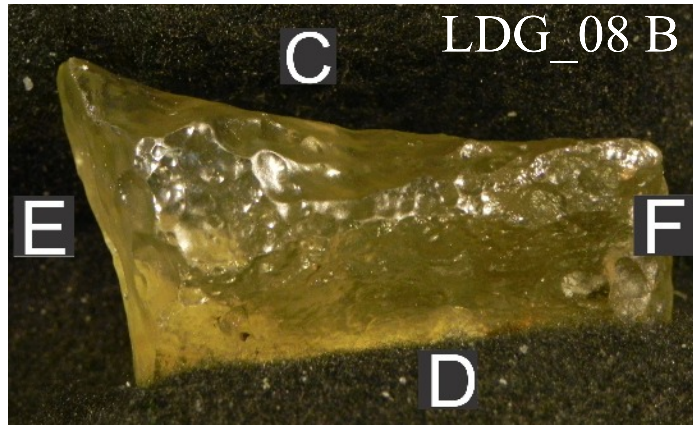


Side B has pronounced curves along multiple axes where the piece was struck from a larger core. These curves from the B side ridge to the C and D edges can be seen in the E and F images at the chapter start. Where these curved surfaces are congruent with the apparent alignment as shown from side A, (i.e. the lower edges where they flatten) the lines of the threads become readily apparent on side B. Where the alignment is farther off up-slope, these are less clear. But even with a considerable slope, some linearity can be seen. It's like fanning a paintbrush - even if only the bristle tips are visible, you can still see which way they're all pointing.

In the above image, the slope of side B at the E and drops off sharply, making an angle of perhaps 45 degrees with the surface of side A. The rim of the drop-off makes a rounded C shape left of center. At the drop-off edge, the predominant linear etching changes to the pitting characteristic of natural glasses. The sides of the crystals no longer form an effective and concerted chemical barrier to the etching agent, and the raw ends erode as if amorphous.

This sample shows structure over virtually every surface. The structure corresponds to my spaghetti bundle model. There is none of the layering shown in the prior sample, so this piece seems to involve threads only. The structure seems to follow a single vector, which persists across multiple surface discontinuities, matches on sides A and B, and does not bend around edges.

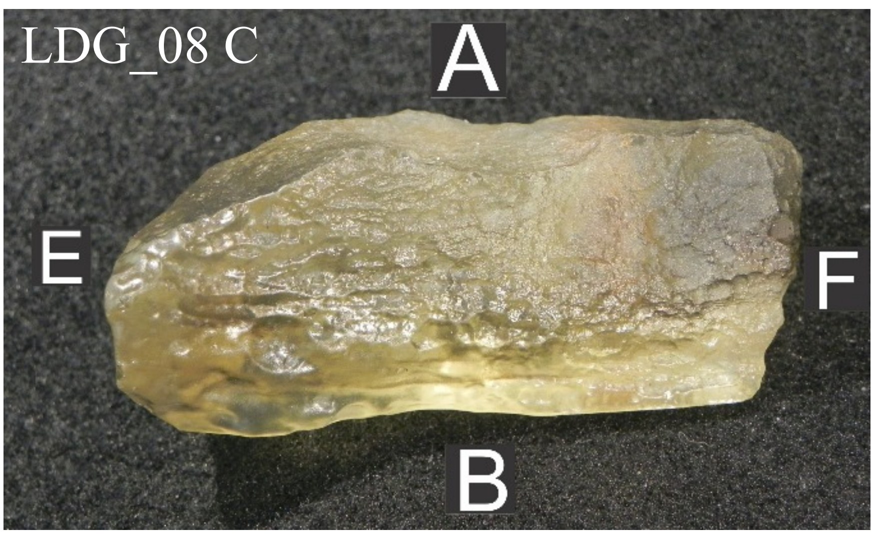


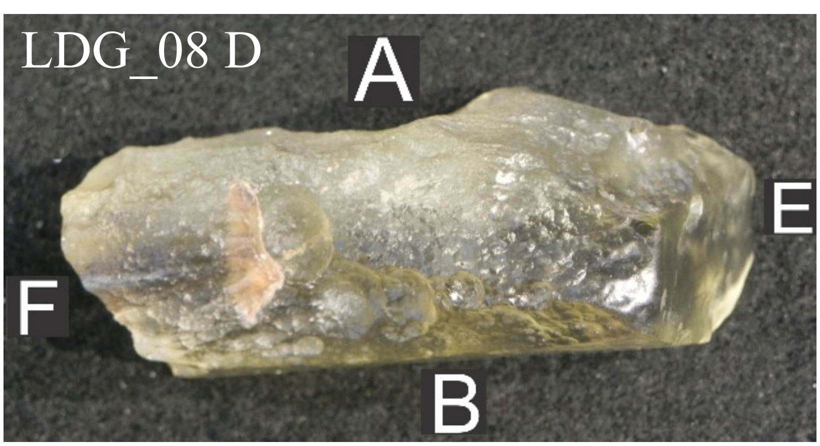


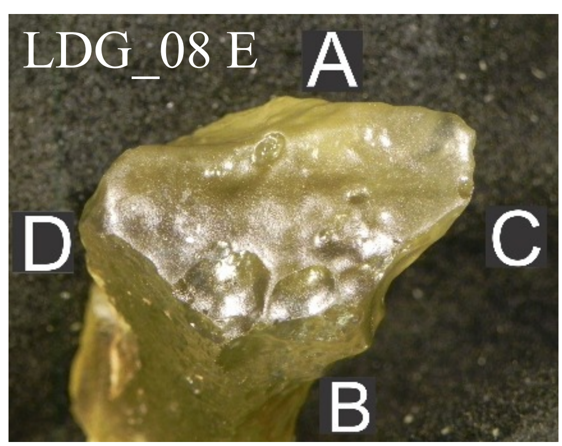
Sample 4 - LDG_08 - Interstitial Bubbles

Based on fracture planes in other samples, I chose this piece for closer examination, planning to grind a flat and look for threadiness. I was completely unprepared for bubbles which demonstrate that there was no molten glass but instead unmelted sand grains captured in fluid.

The item is 2.5” long, and about 1” wide on all four sides except where the taper widens to 1.5”. The A, C and D sides show large striations following the E/F axis. The B side was generally smooth with some small shallow pits. The D side has a substantial leaf cast.





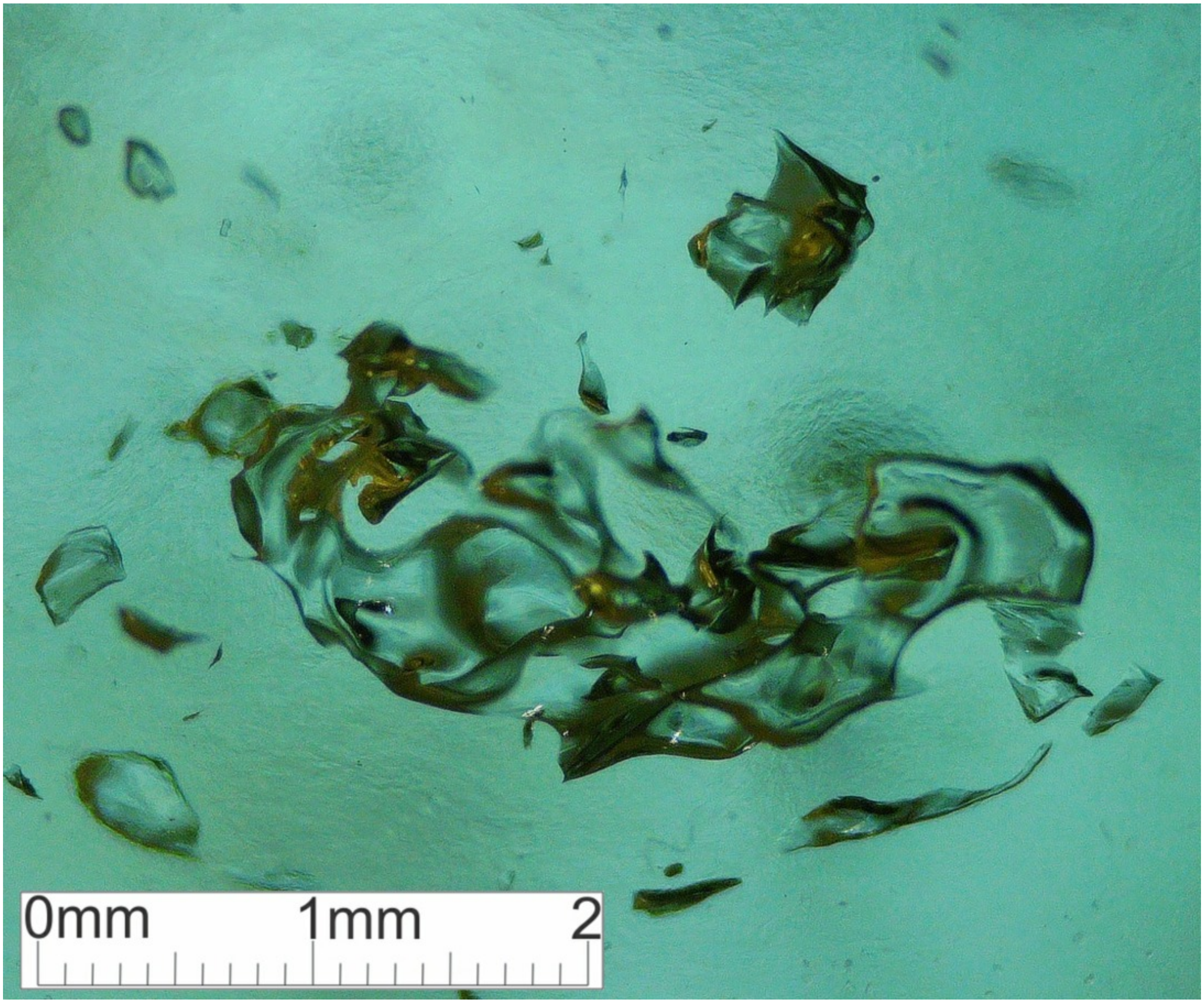


I ground down the B face, since it appeared to define horizontal and was the most boring, to get a vertical view. While there were no visual clues of threadiness, what did appear were these terrific bubbles.

If these bubbles formed in molten glass they might be round, they might be teardrops; if the molten glass flowed they might be elongated. But bubbles in this specimen are irregular and sharp-cornered. They appear to be air left in the interstices between sand grains. That means this material was never molten. The solid grains appear to have been wetted by fluidized silica soaking into the unmelted sand. This is the fingerprint of beta radiation.

The bubble archipelago below (and a similar one following) are about a quarter inch across, and seem to encompass a few dozen sand grains. The sand itself rendered invisible here, so you're seeing only the interstices, and of those only the ones where an air bubble had no escape. Some sand grains can be seen by implication, so to speak.

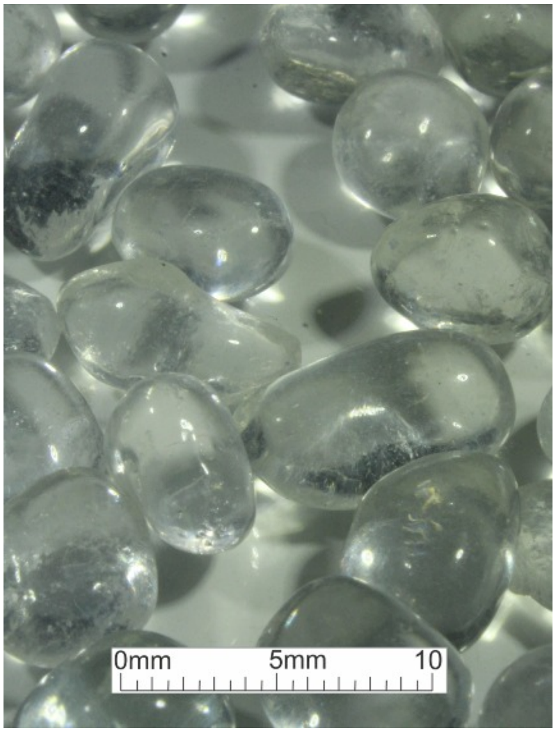
Note the sharp edges where grains meet forming a bubble edge or point. If fluidized silica had significant surface tension and corresponding capillary action, the fluid should wick on through and round off the bubble edges. This suggests the surface tension of fluid silica is negligible at this scale.



Above are two close-ups from the image a couple pages back, showing flat sides and straight meeting edges. Below left is another close-up from the same image, with a bubble appearing to wrap partly around a cuboid grain. Below right is a bubble trapped between several long flat sides.

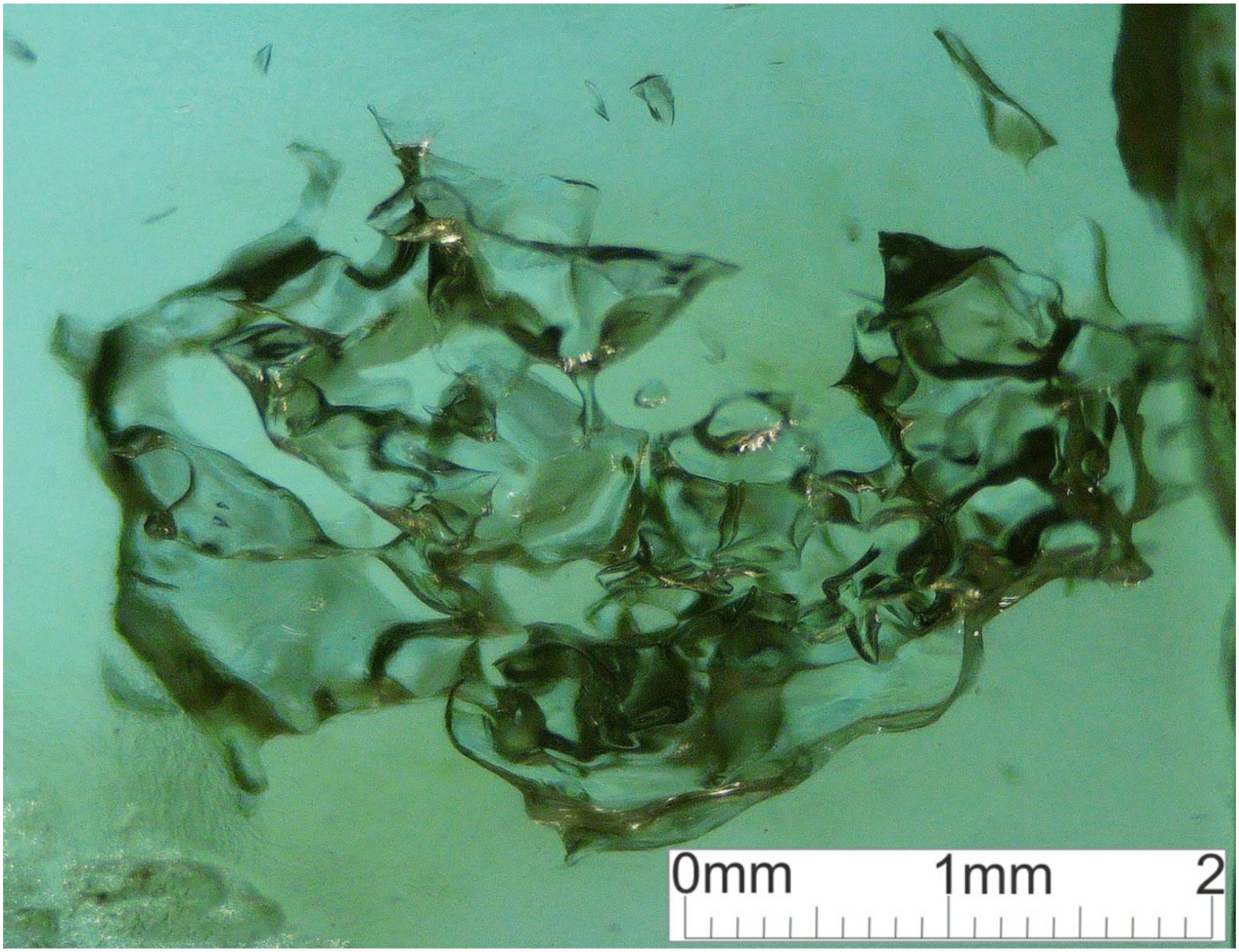
Desert sand may become well-rounded over time from wind transport, and may be pitted. The flat sides and straight edges shown here suggest that the sand from which this specimen formed is relatively cuboid, possibly because it had not been blowing around for long. Judging from the contours presented here, it looks fairly smooth.

To model this with bubbles in a fluid matrix, I used broken tempered glass (smoothed a bit in a rock tumbler) because tempered glass tends to fracture at right angles. I also used round aquarium bedding, and these two example models are about 15x medium sand grain size. I further used small acrylic dice, about 35x medium grain size.



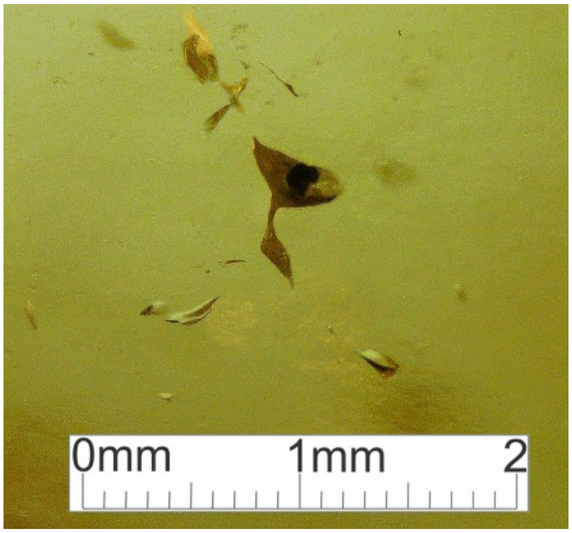
The images above use glass nuggets intended for an aquarium. Bubbles blown through these in Karo show the rounded nuggets. The surface tension and viscosity is not negligible, so these bubbles have rounded points, but the key is how they envelop the grains. Food dye helps the contrast.

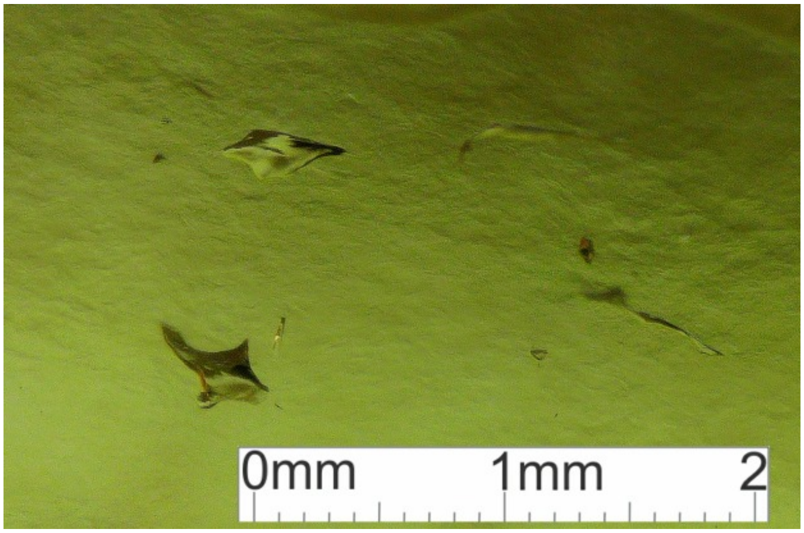
The images below use broken tempered glass, polished in a rock tumbler. The grains have slightly rounded corners and edges but are predominately cuboid. This is also clear in the contours of the bubbles below right, showing grains with flat sides and straight edges.



Above is another bubble complex from LDG_08. Many sand grains can be distinguished by their bubble wrapper. This collection seems to show some flatter sides along with many rounder grains. Just above the center here is a narrow vertical bubble being held by three grains, at least two of them well-rounded.

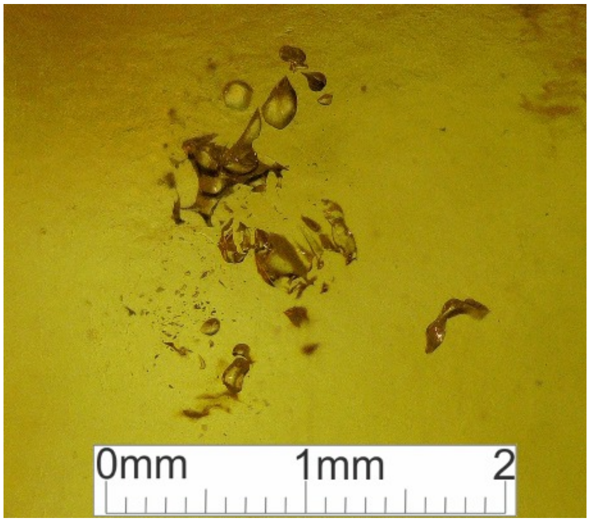
Jazz has been described as listening to the notes that aren't played. Examining these bubbles is like looking for the sand grains that are invisible.





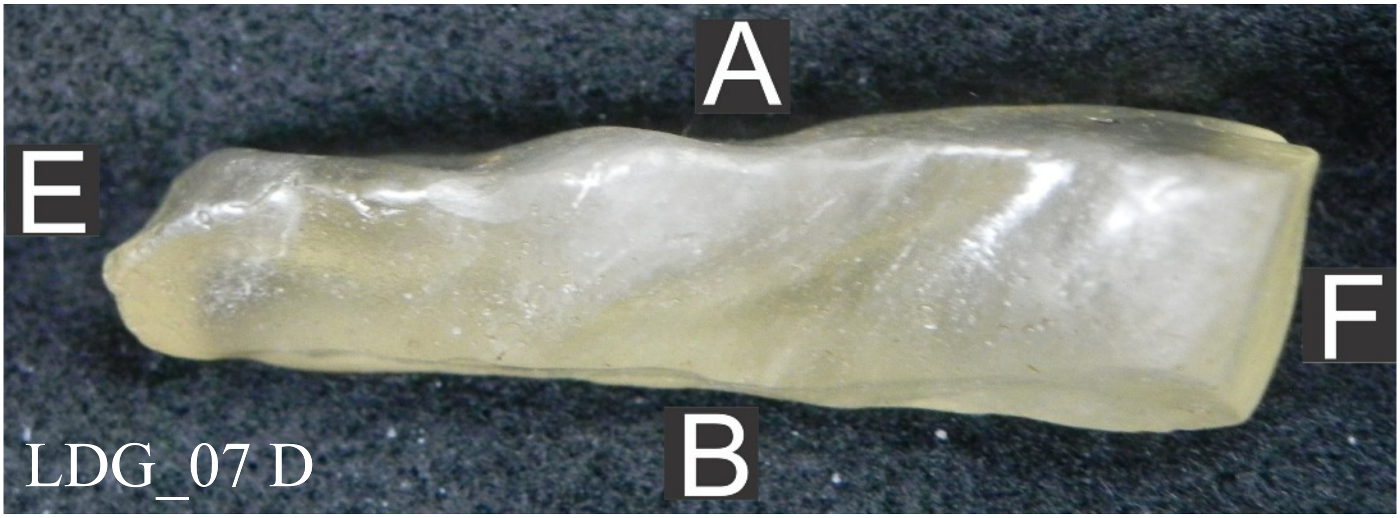
Two more images from this sample again show invisible sand grains by the effect they have on bubbles. The right image shows two bubbles that seem to mark the intersection of at least four grains, like the Four Corners state meeting point in the American west.

Color variations are due to differences in lighting as I experimented under the microscope.



These images seem to show bubbles that have broken apart, perhaps as they worked their way to the top of the liquefied silica before the material solidified and captured them.

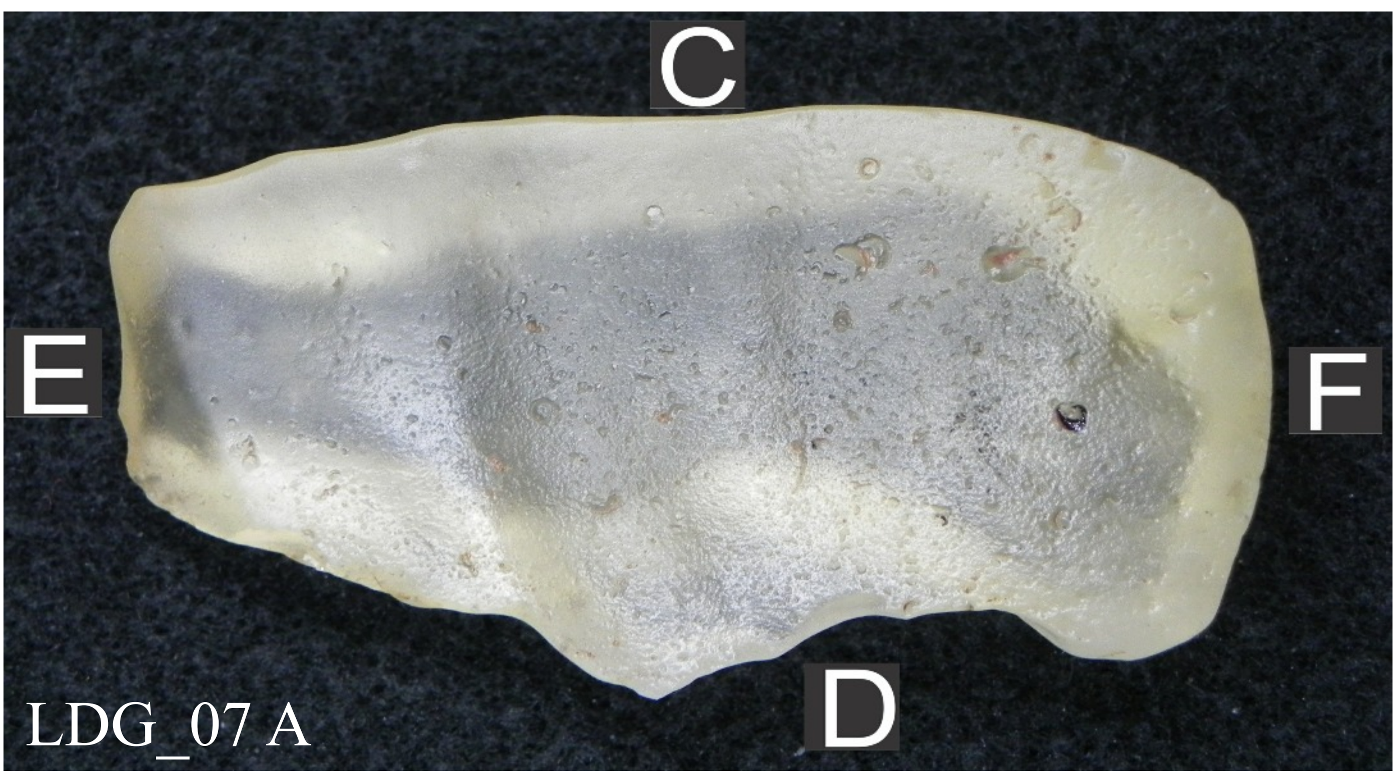
A later chapter presents a collection of bubbles in various of my specimens, including more examples as above. The evidentiary value can be in a single one. If any sand grains failed to melt, yet captured bubbles in interstitial spaces, then a formative event of heat and shock cannot stand.

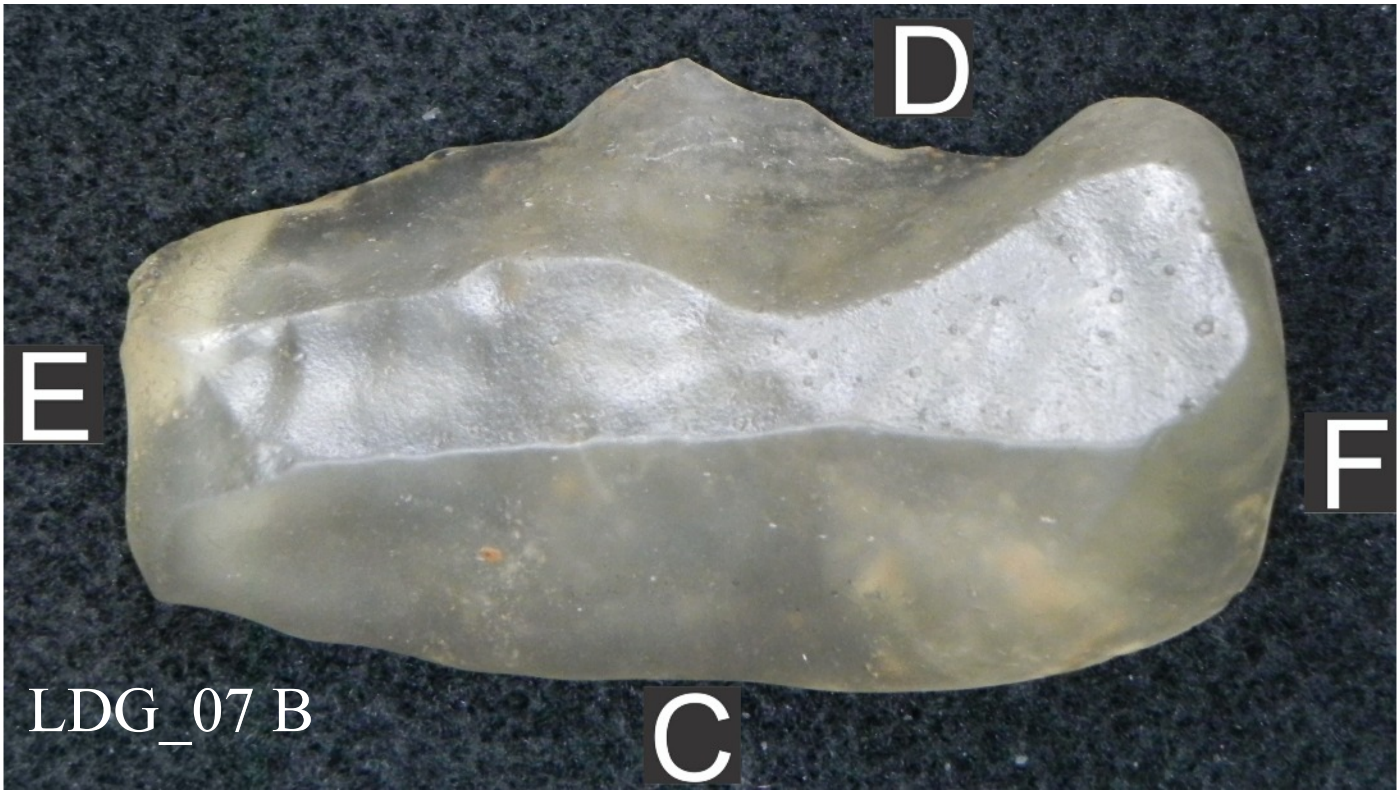


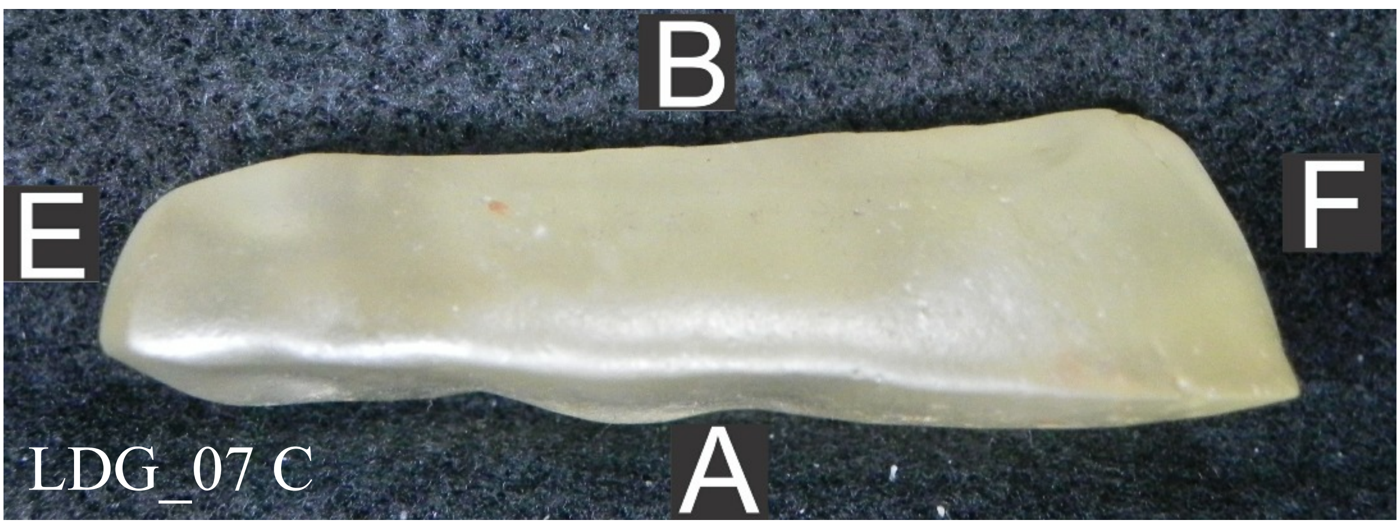
Sample 3 - LDG_07 - Flowed Glass

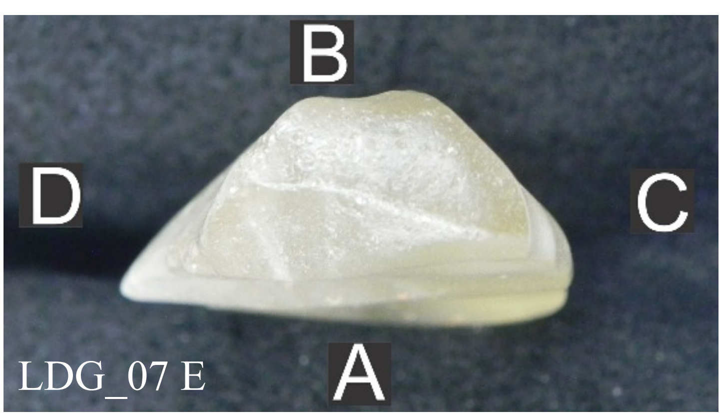
This item shows chains of sand grains which maintain their connection while being tumbled in a flow of liquefied silica. The sheaf of uncooked pasta noodles tangle as if they were cooked. The sample seems to demonstrate my thread-building thesis, but does not directly indicate a radiation event.

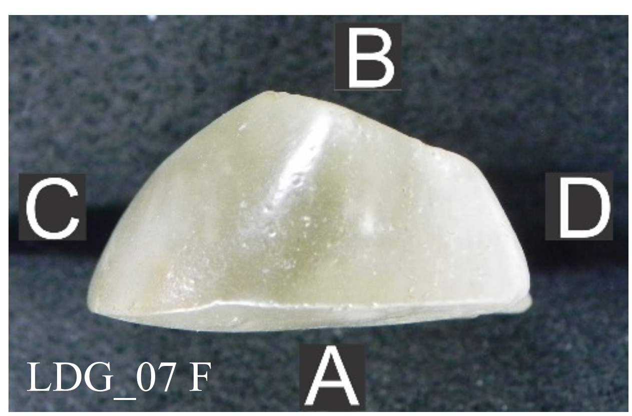
I bought this piece for the ripples, for what might be learned from glass that flowed. LDG_07 is 2.25” by 1.25”, and thickens to about .75” at the F end. What I take to be the original surface is rippled like a pudding skin. The B side has a large flat face where it was split off a main block. Two long smooth facets make a bevel to the C side. The C-A and D-A edges are the most protruding and are eased by weathering, with a sharper chip off the D side from a recent break. The entire surface is smoothed somewhat but the edges are not profoundly rounded.




D
E
F
LDG_07 B
C


B
E
F
LDG_07 C
A


B
D
C
LDG_07 E
A

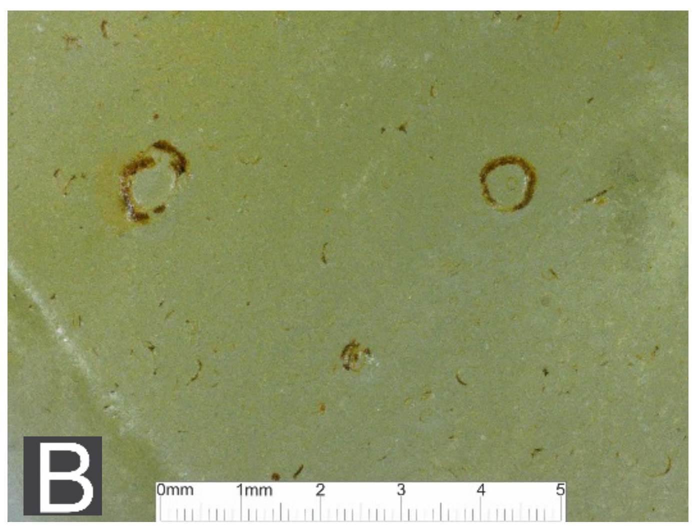

B
C
D
LDG_07 F
A

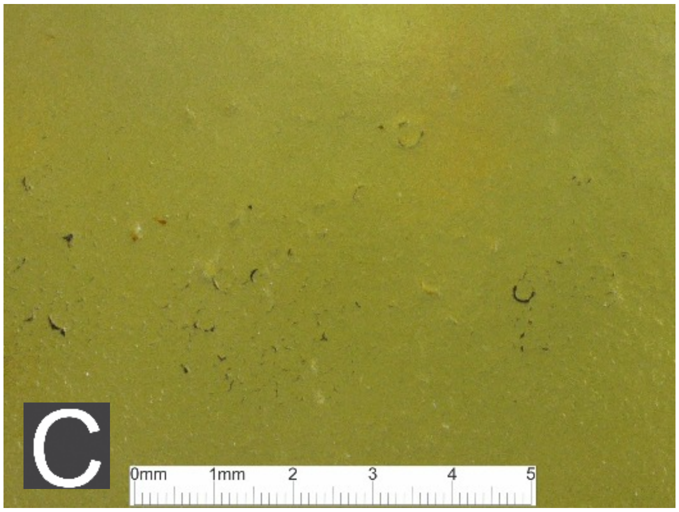
The most striking feature of this piece is that every surface has a scattering of circular or semicircular depressions with a prominent central bump. There is not a single example of the deep pit that seems to be left where a rounded grain was removed. So these do not seem to be objects being freed from the glass by etching, but instead are domains of the glass which are resisting etching. I suggest these are crystals which present a rounded face as they emerge from the surfaces. The boundary between the crystal and the surrounding amorphous body seems to be a zone of vulnerability to the etching agent.

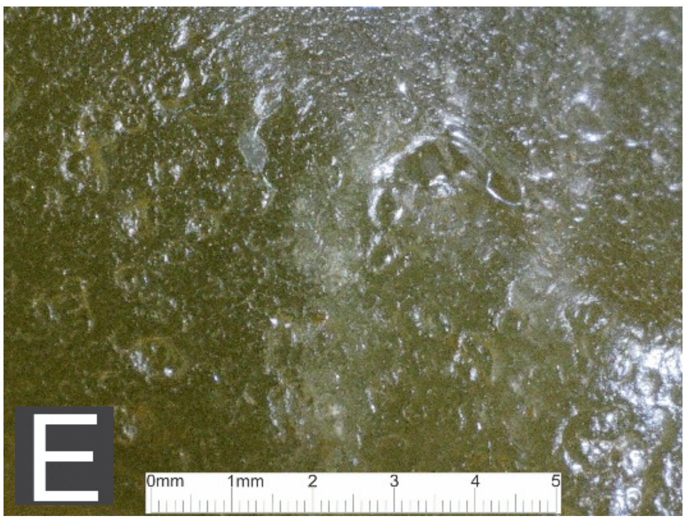
The question for my discussion here is whether these have any evidentiary value. They might be random lattice survivors of the creation event, whether heat or radiation, perhaps grown through devit. They might be newly appearing crystals spawned by devit. Or they might be threads following my model, again perhaps grown over time.

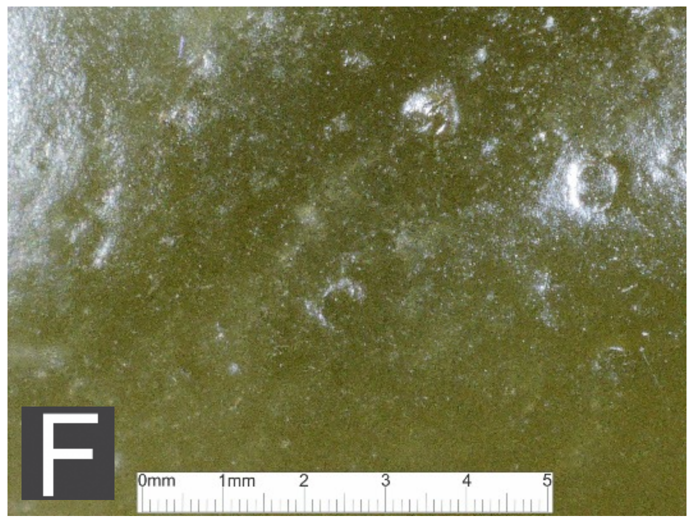
The surfaces have been abraded and apparently knapped, so we're looking at a random sampling of these objects being progressively sectioned. The etching agent has eroded a groove around each, deep and narrow enough to hold the native reddish clay that here serves as a dye, but not so deep as to look like a cylinder boring into the body. In other words, the etching agent erodes this vulnerable zone preferentially but not obsessively. The etching doesn't carve around the back and pop out a deeply embedded object. However, it should be able to extract the lowest slices of the embed, once the sectioning has removed most of it, and the possibly spherical curve of the object leaves a progressively smaller circumference to be cut. Shallow pits should show where this has happened, if these were roughly rounded.

The ratio of these pits and their depth would tell us something about the geometry of the embeds and the strength of the etching agent. There are innumerable very shallow dents, which could be such pits or could be random weak spots as found in any etched natural glass. But pits large enough to match the diameter of these visible rings are vanishingly few. The image of the A side shown below left has one of those in its lower right quarter.



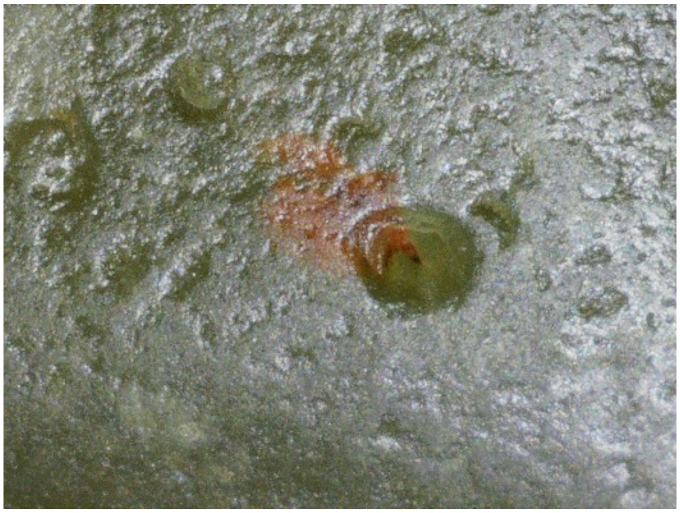






To find so many of the circular and semi-circular marks and so few pits suggests that the objects are relatively deeper than their diameter. That is, if there are few bottoms being exposed as pits, and many objects overall, then the bottom aspect of each object seems to be a relatively small ratio to its size. In other words, these look a little thread-like as they poke out.

A second reason to see them as being long and narrow is that they seem to have an orientation as they emerge from the surface. Where the eroded ring is complete, the etching agent found no difference in vulnerability on either side. But where the ring is only partial, it's tempting to say the object is oblique. I have no way to measure that for any given embed, it merely makes sense within my model.

The above images are interesting regarding the objects' angles. This instance is unusual in being eroded so far. It has a somewhat elongated hole opening, and when lit from behind shows a deep pocket highlighted by the red sediment. It being the only one, I can't say it should mean much.

In sum, these features suggest that threads might be involved. They are at least not in conflict with the thread model. My thesis does not require that threads or crystals be seen in all samples, or that threads will always appear as linear bundles. My thesis holds that where apparent crystals DO resemble a spaghetti bundle, they will not violate that model from any aspect.

If these apparent thread ends were on two faces, they could be explained as linear threads going in one side and out the other. On four faces they could be a group of parallel threads on the diagonal. But it's curious that they are also rising out of what looks like the original surface, here the A face. And on all faces there are at least some that are circular, meaning not oblique.

If we provisionally treat these as threads, what does it tell us?

Since they are on every face, they were apparently subject to quite a bit of turbulence as the silica flowed. That would imply that the flowing was not a matter of a few centimeters, but was enough for complete overturning of the dollop, perhaps with stiffening to a topside ripple happening late in the process. Nothing remarkable about molten sand flowing freely in a significant heating event, or liquefied silica under radiation, but for crystals to be tangled *during the event* means that long and slim crystals must have formed very fast and early. The thread model gives a mechanism for such fast crystal formation.

Early attempts at optical glass were stymied by devit, and once it appeared in a batch it was not possible to remove. Presumably those problems have now been solved, but once it meant spectacles had to be made from quartz, for example. While surface devit can be cured by fusing a fresh layer of glass, internal flaws are less redeemable. Once crystals form in molten glass they resist destruction. And if this was a radiation event, then crystals will remain intact if the exposure is below the crystal-liquefying threshold.

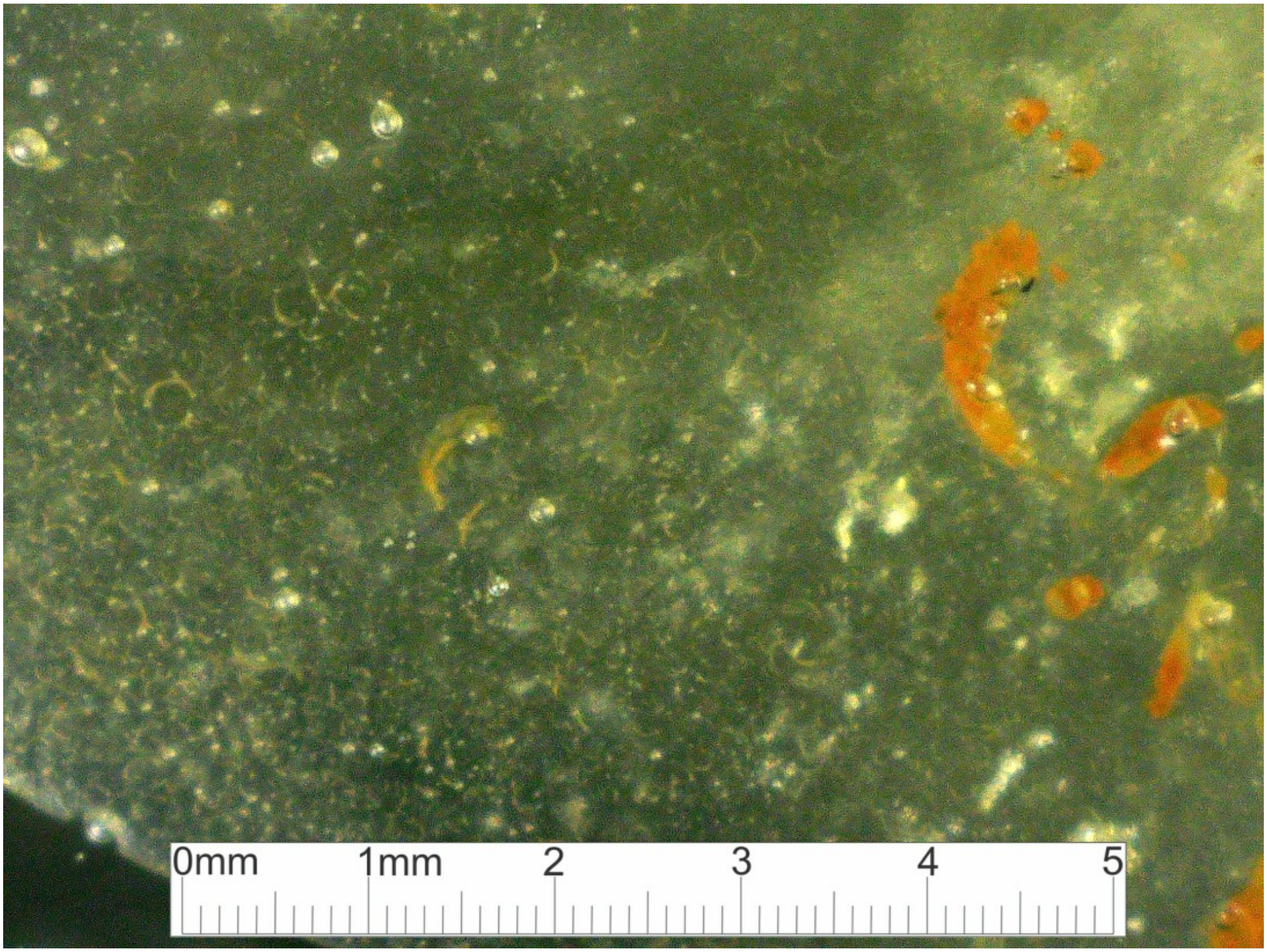
The most plausible scenario (within my model) is that threads formed early and were not destroyed by the turbulence of the silica flowing. The threads might be as crystals, or as sequences of aligned grains that could devit into crystals later and were not stirred enough to render all the sequences chaotic. If my thesis fails to hold water, then of course these circles must have some completely different explanation.

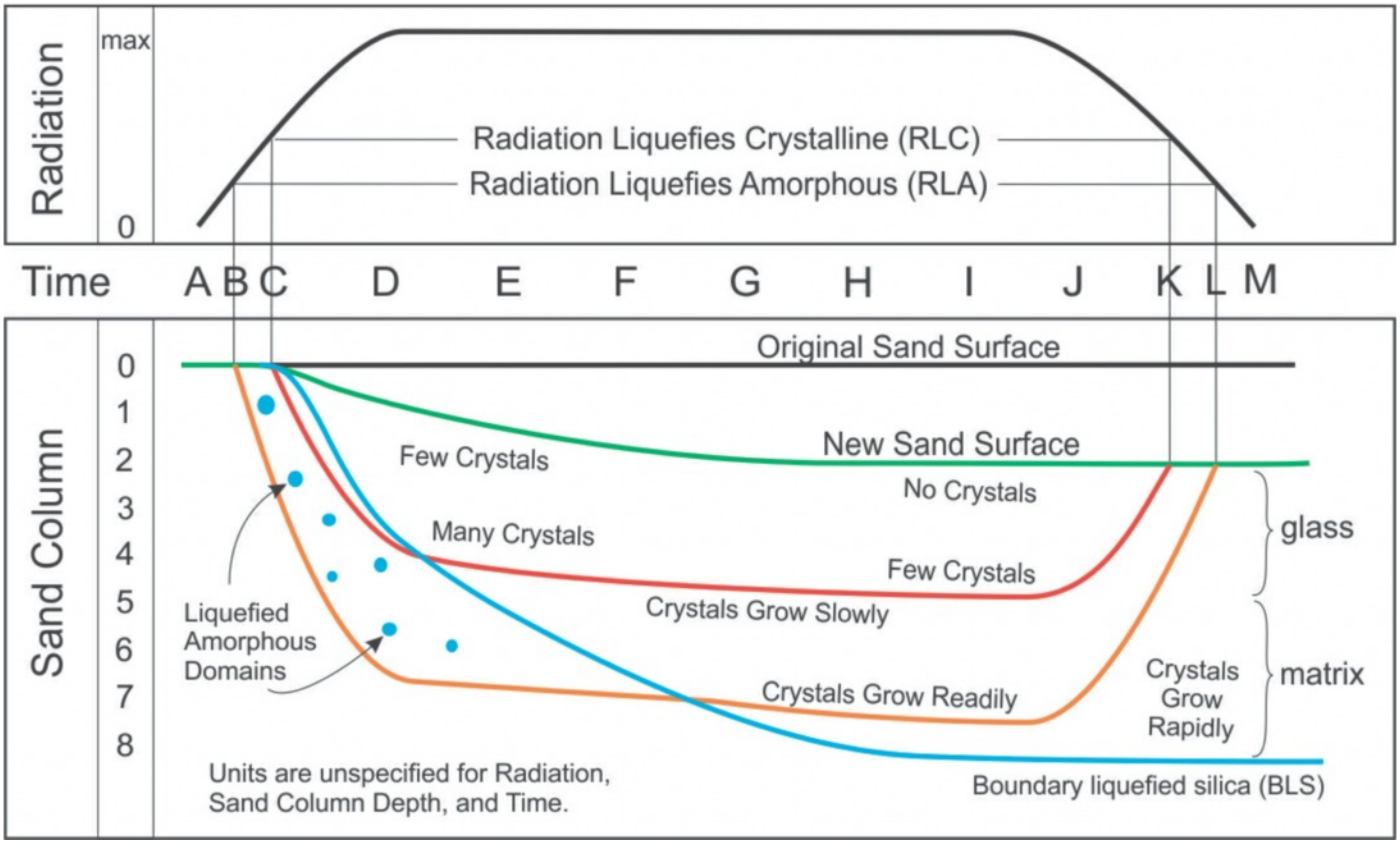
If we frame these features as the ends of crystal threads, they seem too few and too fat. Under magnification as in the image below, it turns out there are many more of them, and the size varies widely. On the right is a partial scar of a 2- or 3mm circle, while on the left are many scars about .2mm, an appropriate diameter for sand grains. Interestingly, these smaller ones are also circular, as if there was little competition for space.

A workable model for this sample is quick-clay or an avalanche. Quick-clay has a structure that is stable under static load, but once a small collapse is induced the whole rapidly liquefies. Snow is solid until a block of it begins to slide, whereupon the whole becomes entirely fluid until there is no more downhill.

When the liquefied silica drained into this sand, it would have remained stable in the normal course of events. But this sample happened to lie at enough of a slope to start moving once wetted, or some nearby disturbance was enough to stir it. Once the movement started, the liquefied silica flowed between the threads and the threads moved apart. The free liquid was the lubricant, and the sample lost all strength. Once this happened, it began flowing and overturning until it ran out of slope or the liquefied silica set up.

During the time it was flowing, there was variation in the sand grains and the liquid. Some of the sand threads were surrounded by more liquid silica than others. These crystals grew by accreting the free silica, and the speed of their growth was a measure of the unevenness of the liquid/grain balance in domains through the piece.





Crystals in the Sand Column

Returning to the sand column timeline, we can flesh it out with what the crystals are doing. The radiation event takes from Time A through Time M. The radiation level rises first past the point that amorphous silica will liquefy, then past crystalline silica, maintains that for some indeterminate time, and falls again.

Throughout this event the radiation is strong enough to have these respective effects at some depth in the sand column. Between Times B and C the radiation is strong enough to liquefy random bits of amorphous silica which wet sand grains they are contacting. Between Times C and D the crystalline silica begins to disintegrate and wet remaining grains, and as those too disintegrate the fluid silica drains downward.

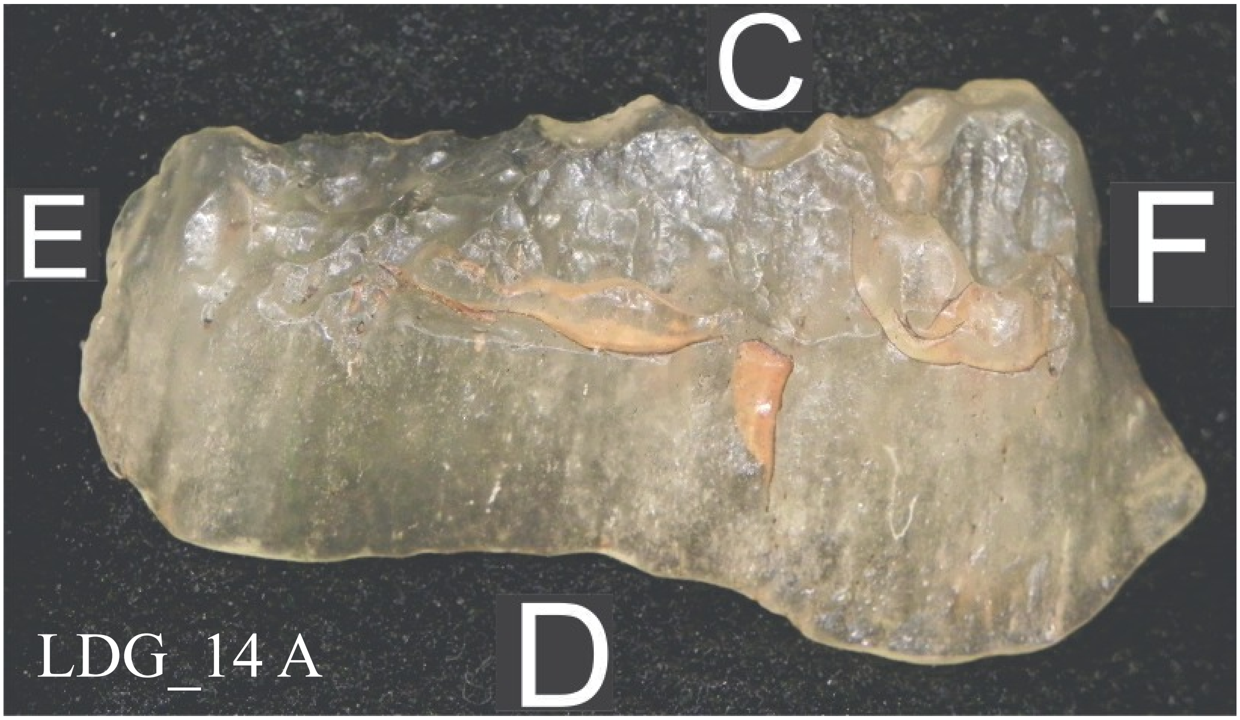
Crystal disintegration is not instantaneous, so there is some span in Time C-D-E where it is happening. The downward flow is limited by the fluid's viscosity. The radiation is stronger at the top of the red-bordered area, and disintegration is more complete and faster. Near the red line the radiation is attenuated by overlaying silica, more crystals remain and fail slower. In the H-I-J-K range there are no crystals left near the now-dropping surface, and few near the red border.

The fluid silica below the red line is still irradiated enough to maintain a liquid state, though not enough to disintegrate it if it were crystalline. At the same time any amorphous silica there is being liquefied. But the mass within the orange boundary is full of crystalline silica, and the free silica accretes to the existing crystals.

There is no equilibrium for crystals in glass. Crystals will either disintegrate or grow, and within the orange boundary they will grow. Near the red line they may grow slowly, but as the radiation is further attenuated they grow more quickly. During Time J-K-L-M, any liquid silica will rapidly accrete to existing crystals until it sets up.

I have no evidence that this sequence of events is valid; it's merely a graphic representation of what I'm proposing. One implication of this model is that crystals will grow rapidly during the radiation event, in contrast to growing via devit after the event. The circular marks in the present sample suggest that crystals were surrounded and spaced apart by fluid silica during the event and have not grown to collide since that time. In this respect they seem to support this model.

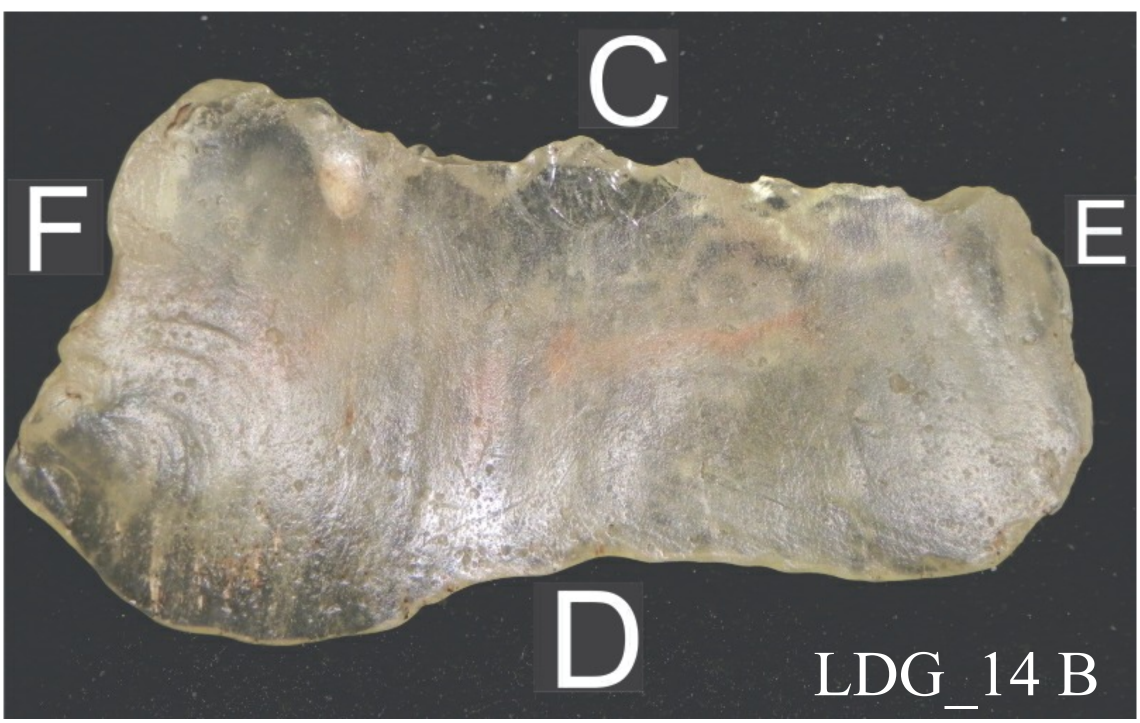
This is the last sample purely focused on the LDG structure. The remaining six specimens contain fossils. The presence of fossils (particularly the ubiquitous leaves) clarifies the forces at work and argue against LDG ever having been molten. At the same time, most of the remaining specimens also display the threads which are the basis of my proposal.

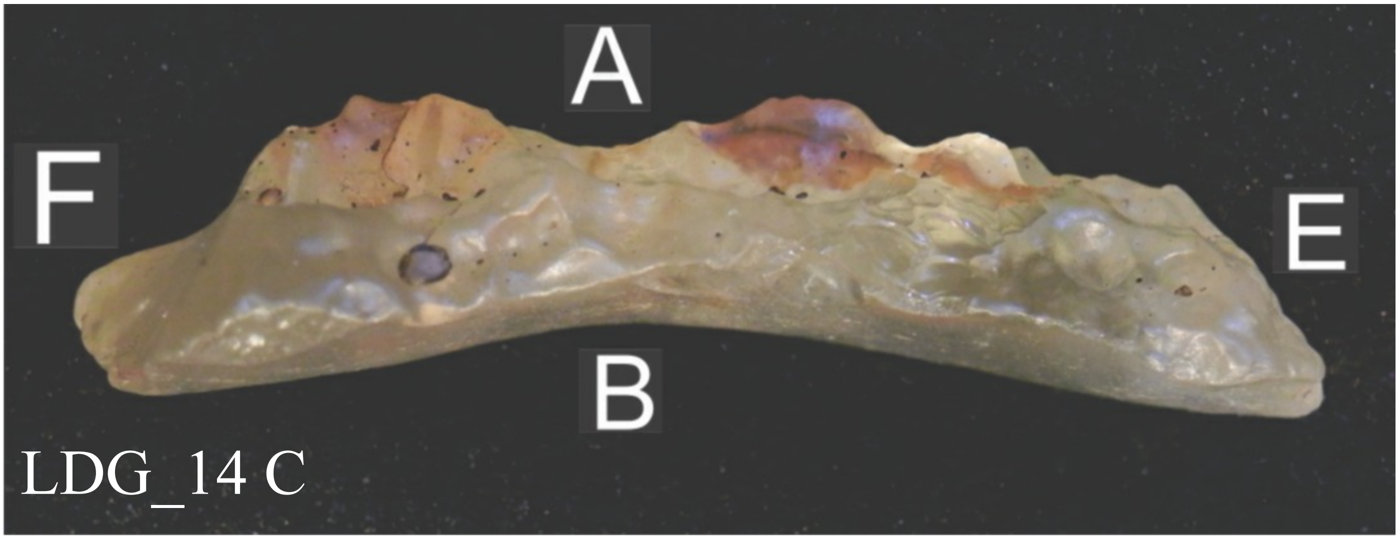


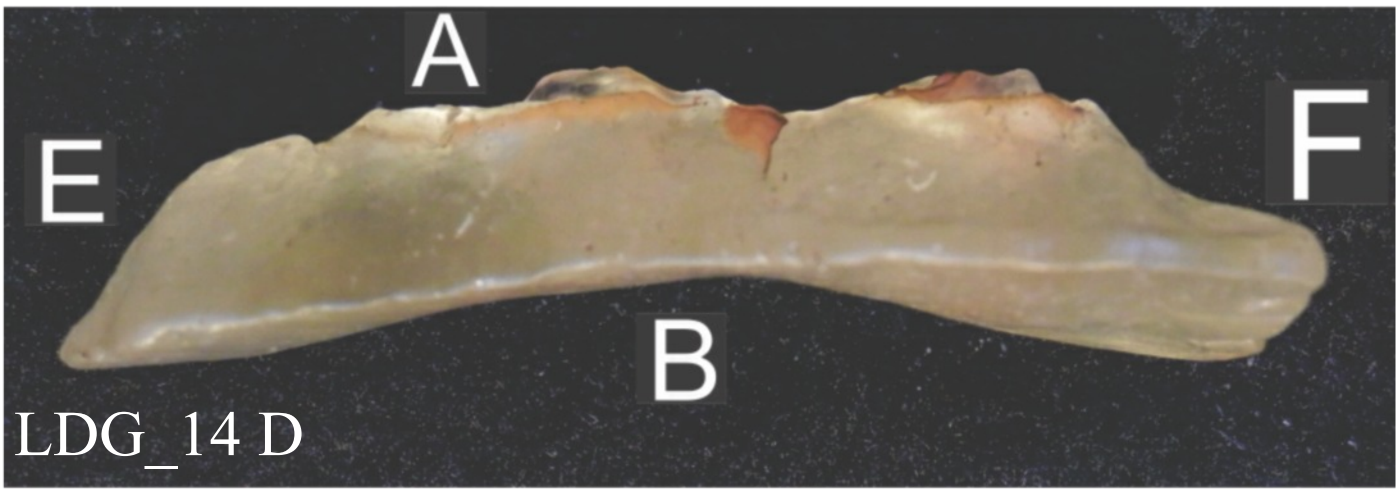
Sample 5 - LDG_14 - Leaf casts

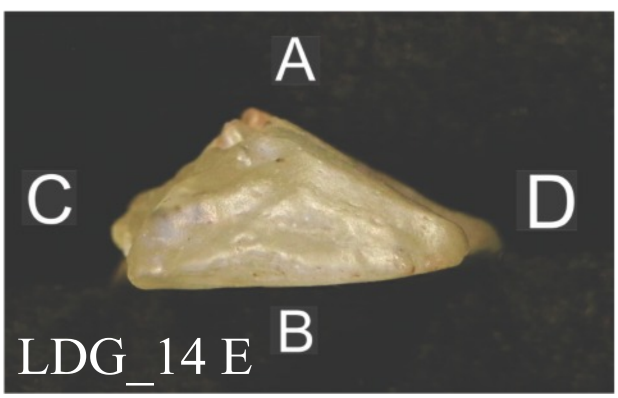
This 2.5” by 1.25” specimen covers many bases. It fleshes out the vegetation picture of the site. It adds to the evidence against a shock and heat event. It gives only minor support to my thread-crystal model. It graphically shows the human interaction with their tools. And it leaves us with an intriguing puzzle.

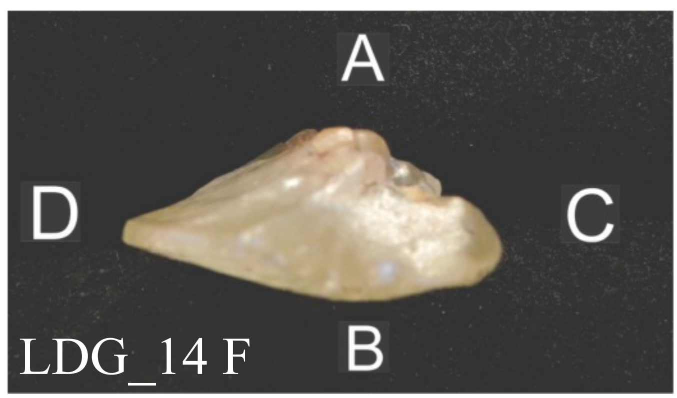
The A side above has two faces, one very smooth and regular toward the D side, and one deeply pocked toward the C side. At the ridge between those two are the casts of leaves. The B side below is the apparent original surface of the dune. It is broadly curved inward in the center, with a large and weathered conchoidal scar at the larger F end.





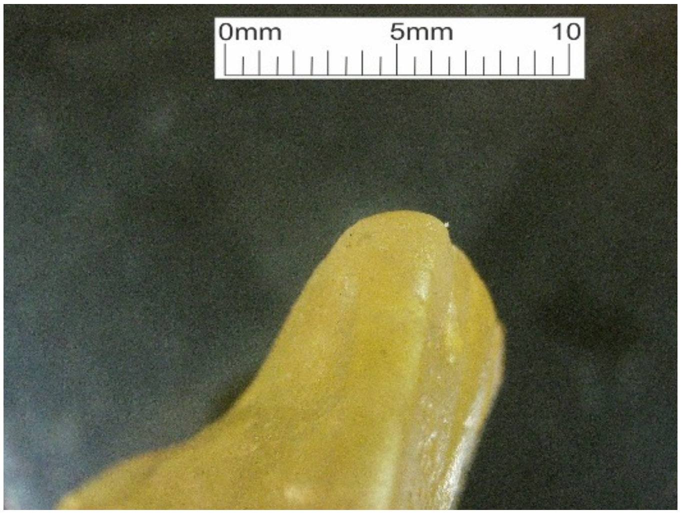


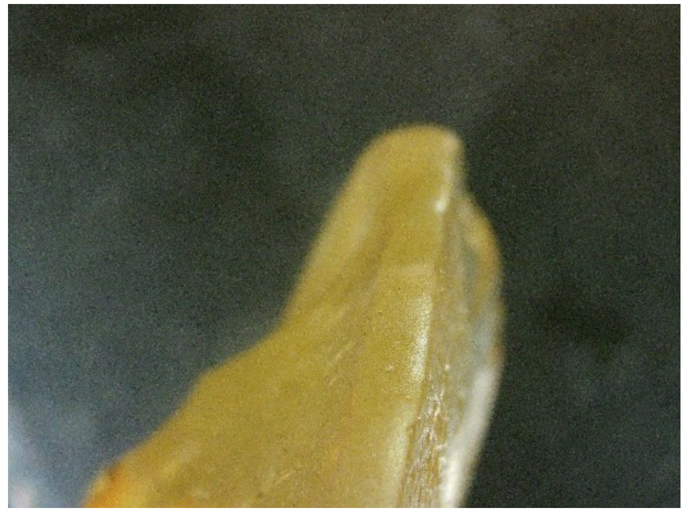




There are two leaf outcrops to cover. As seen in the A image on the prior page, going left to right, they are a long wavering specimen (“the Wave”), and a twist of possibly multiple parts (“the Whorl”). As shown in the C and D images above, they are well below what appears to be the original sand dune surface of side B.

Since this specimen’s use as a scraper will keep coming up in discussion, I’ll cover that first.

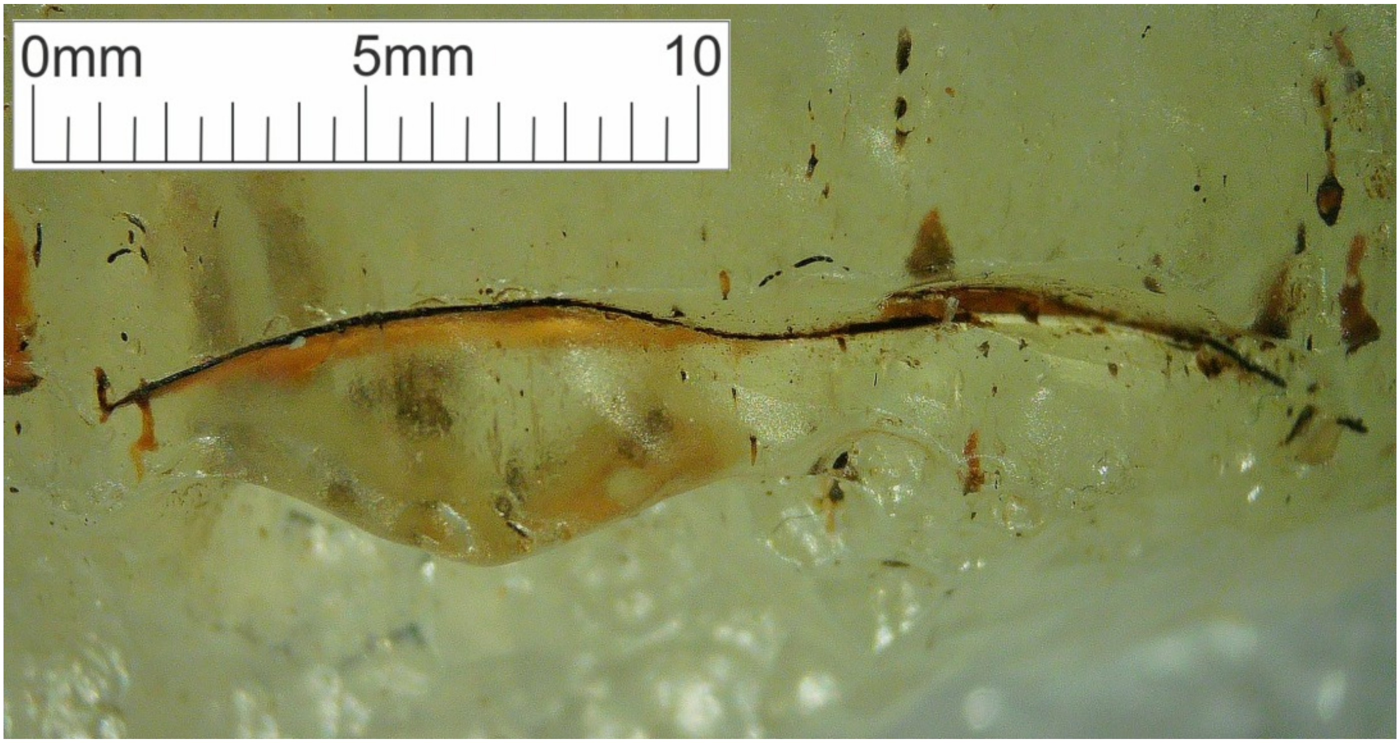


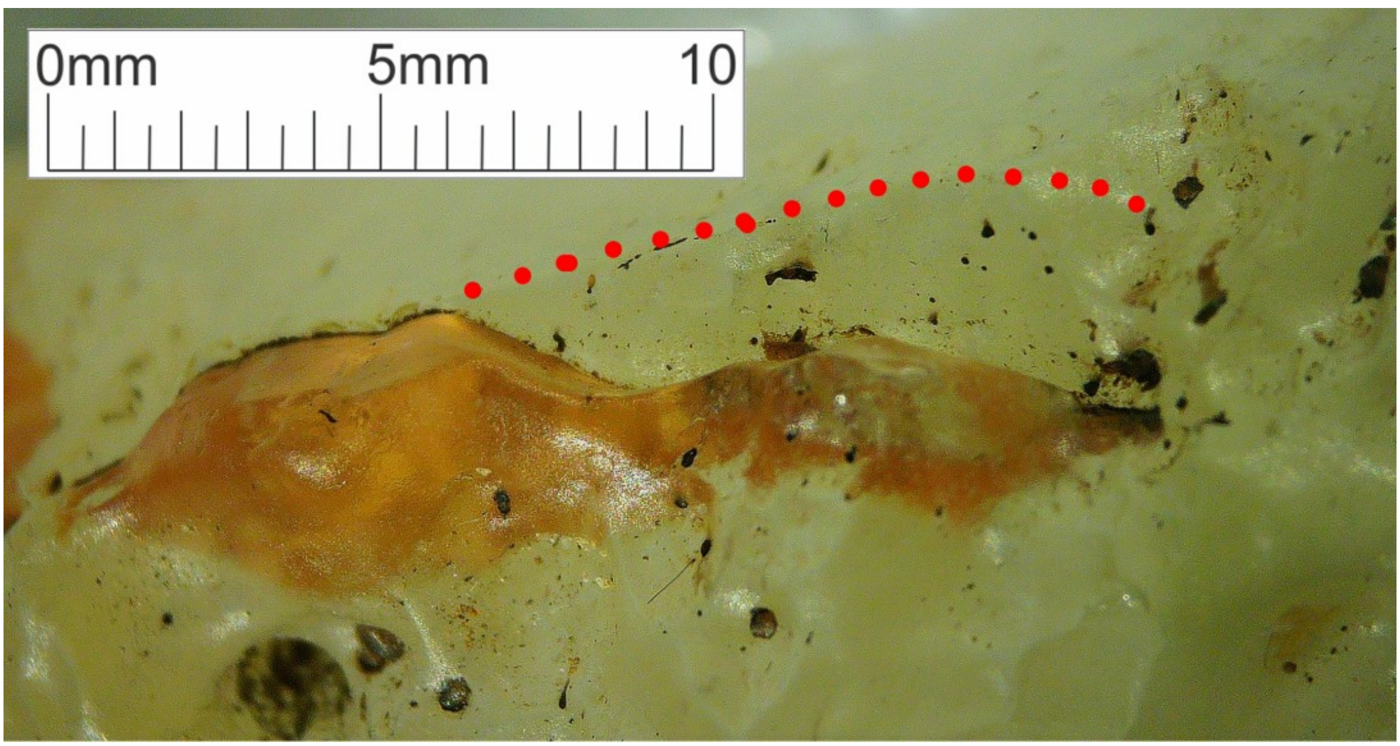


The above sequence shows the D edge starting at the F end and working toward the E end. The A side is at the left, B on the right. The focus (and scale) applies to the center of each frame. The curve crowning the edge is not natural rounding. There is a distinct curve change on the left side, sharpening to a cusp in the lower two images. The right side is a sharp cusp the entire distance. The piece was clearly held in a consistent manner, with the D edge nearly vertical on (presumably) a skin being scraped. The scraping was from the right to the left, in these images, with the leading edge rounded down by friction and the trailing edge showing no wear.

The B side (as shown on a previous page) is unremarkable, except for its large shallow conchoidal scar. The deep dish in the middle makes for a comfortable grip. The A side meets the B side at a long very sharp cusp (the D edge), but there is no sign of knapping, no mid-size flakes taken off. The A side between the D edge and the F end has long shallow pits, but on the whole it makes a smooth slope from the middle ridge where the leaves are.

Small flakes have broken off the trailing edge of the scraper, on the smaller end of the piece. They don’t look organized or intentionally removed, but probably resulted from stress while using the tool.





The Wave leaf structure makes a curving line along the A side ridge on the smaller (E end) of the piece. The void in the specimen has the reddish look frequently found for silt associated with LDG, so that's probably what we're seeing. The first image views down along the plane of the leaf, and the second looks from the C side. Compare to the A picture at the start of this section to see that the leaf plane is considerably sloped with respect to the presumed dune surface B. The red dotted line marks the upper edge of the leaf's plane where it intersects the rest of the A surface. It would have been brown if perhaps someone hadn't pushed too hard while scraping and broke it off.

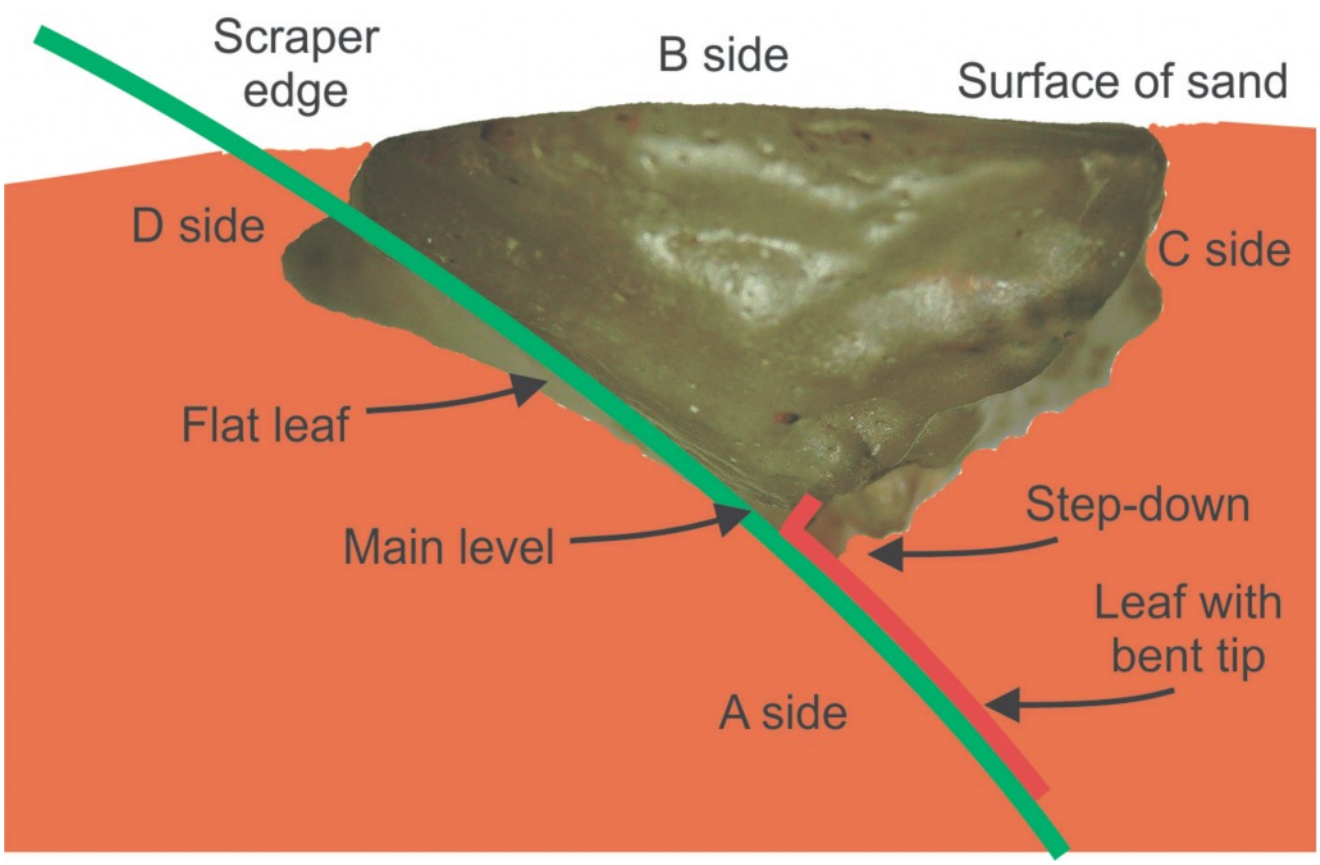
The exposed edge of the void and many small pits in the area are covered or filled with black hard deposits which might be relics of this item's life as a scraper - sweat, body oil, animal fat - and/or possibly something like pollen. I have not seen this material on any other specimen. There are many very deep pits on the A side facing the C edge, and they are commonly filled with rounded sand grains cemented in place with this gunk and finer particles. I don't know if there's enough biologic material to identify or date.

These brown structures are not cracks but voids, apparent casts of leaves. They don't fade at the extreme inner edges, as a narrowing crack would do, but (judging from the brown color intensity) maintain their full width up to the terminating edge. Being voids, they do not tend to advance as a crack in glass would when stressed. The fact that this was used as a scraper (long enough to round down the D edge) attests to their robustness.

The lump remaining at the left end of this curve illustrates the strength again. The image above left shows three marks below the top. The left one is a very deep hole, the second is a shallow pocket with a speck at the bottom, and the third is an even smaller pocket and speck. In the image above right, the deeper pocket can be seen on the left side looking like a band of shadow going all the way past the leaf plane and a couple millimeters farther. The second pocket is not deep, but the recess under the overhanging peak is so great that the pocket is virtually touching the lower extremity of the brown layer at the center of the right image, leaving no discernible gap. If this void were a crack instead of a cast, such a concentration of weakness should be fatal.

The most remarkable feature of this leaf cast comes in viewing the promontory from the side. The top of the overhang is level with but below the A surface in this area. The outcrop is not merely worn more, but distinctly steps down at the leaf cast. The offset is a plausible thickness for a leaf. Add to that the fact that the A side is quite flat, with no sign of knapping.

Returning the specimen to its original orientation as below shows the cause. As a bush was being covered by blowing sand, the large flat surface on the A face is the side of a leaf still partly emerging. The sand holds it against a second leaf with a fractured tip. The blade-shaped D edge which became the scraper blade was the meeting place between the large leaf plane and the dune surface. This gave a scraper blade without having been knapped or fractured. And the step-down of the promontory is the portion of the bent leaf which was pressed against the larger leaf, giving us a gauge for the thickness of the second leaf.



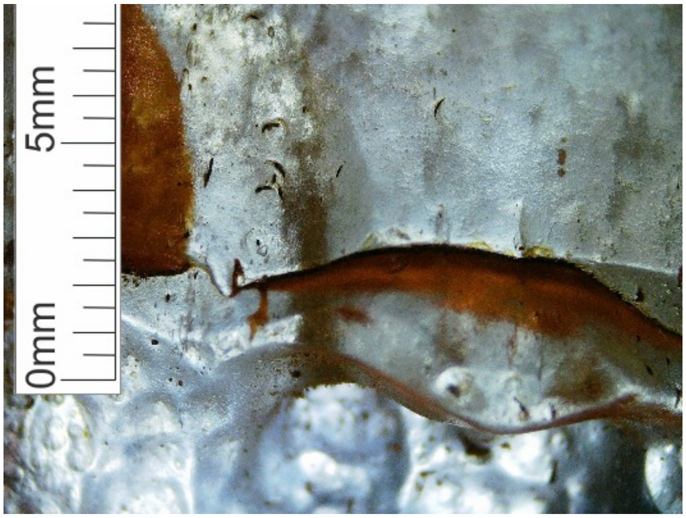
Toward the F end on the A side peak, the Whorl seems to show the tips of multiple leaves curled up and presumably desiccated before the formative event. The above left image looks roughly along the plane of the leaves, angled to show coloration under the surface. The right image is from the C side where all the deep pits are, showing pits running under the leaf voids, clogged with cemented sand grains. With the refraction from the glass, it's tricky to see just where the connecting tendons have remained to hold this nearly separated collection together. Yet it survived thirty million years, including yeoman service as a tool.

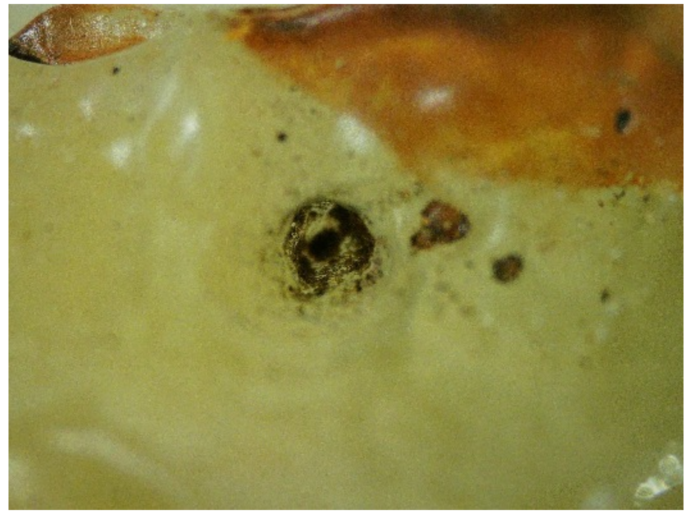
Viewed from A plane in the image below left, these voids show the same step-down structure as did the Wave. In this case there are multiple steps. Clearly there was a large flat leaf forming the A surface plane, with a step-down for the first Whorl leaf, and another step-down for an inner leaf. We now have enough data to understand what we're seeing in the image below right. A large leaf was emerging from the sand, and had more leaves pressed against it. Where those dried leaf tips were bent at an angle, they were captured in the glass and remain as voids. Where the dried leaves were flat, they left no individual trace.

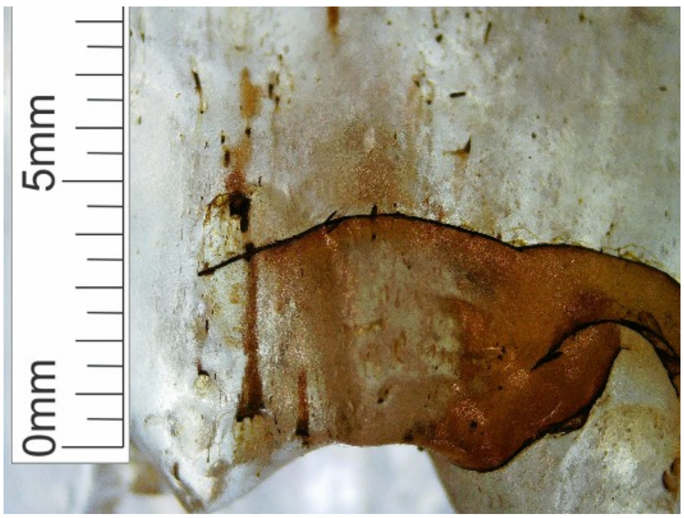
The triangular fragment on the right side of the below-right image appears to be a fragment of a large flat leaf that formed the A side slope. The slope is less regular than that on the thinner part of the specimen (touching the Wave), raising the possibility that we're seeing a sheaf of flattened leaves here. Several may have protruded from the sand, but the only ones we can be sure of are the few that left fragments as voids.

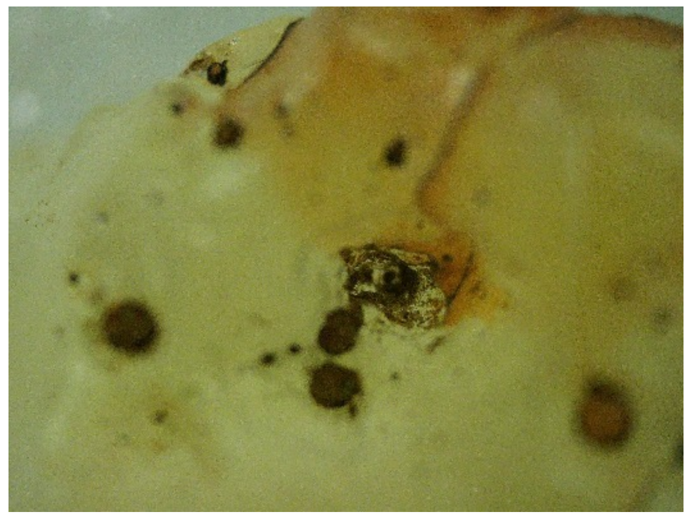
This specimen suffered virtually no natural wear. The fine detail in the Whorl step-downs, which is a prominent point on the peaked A side, shows no water tumbling, no abrasion from wind-blown sand. The E and F ends would be worn down in water, but the E end in particular has small sharp points that are not the result of flaking. Similarly, the piece shows little or no chemical etching. The large flat A side slope facing the D edge has no significant pitting, and the B side (the original dune surface) has none.

On the other hand, the A side slope facing the C edge is a mass of pits. Given the immaculate preservation of the rest of the item, it seems reasonable to presume this face is close to its original state, minus wear from being gripped as a scraper. The top image above shows a series of small points flaked off on the lower edge just to right of center leaving glossy conchoidal scars. This might be damage from the collection handling. Other than that, this face has a series of peaks that are moderately pointed but not really sharp.





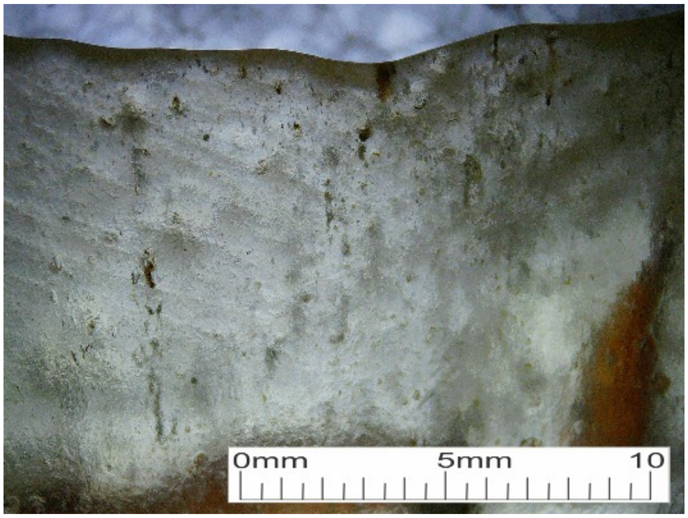


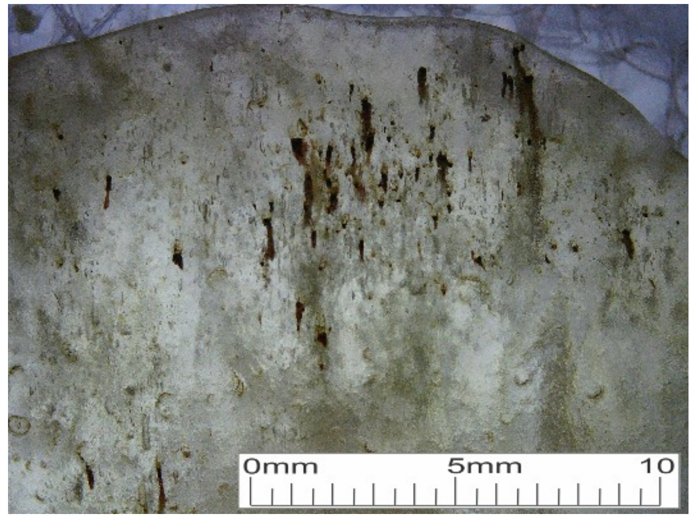


Two pits are pretty deep. The one under the Wave (top) is about 3 mm from the lip above the opening to the back of the recess. The one under the Whorl (bottom) is about 7 mm. Both have no perceptible taper. I suggest these are casts of some kind of stems. There are many smaller pits, mostly plugged with sand grains cemented with black sludge. The reasonable explanation is hairlike protrusions of leaves or seeds, such as the brushy top of wheat grains or the like.

There are some pronounced ridges under the Whorl opening (above). In another context they might be interpreted as the crystals I've been pursuing here. But the number of deep and shallow pits sharing an alignment suggests that these are just a cast left by some stems bunched together.

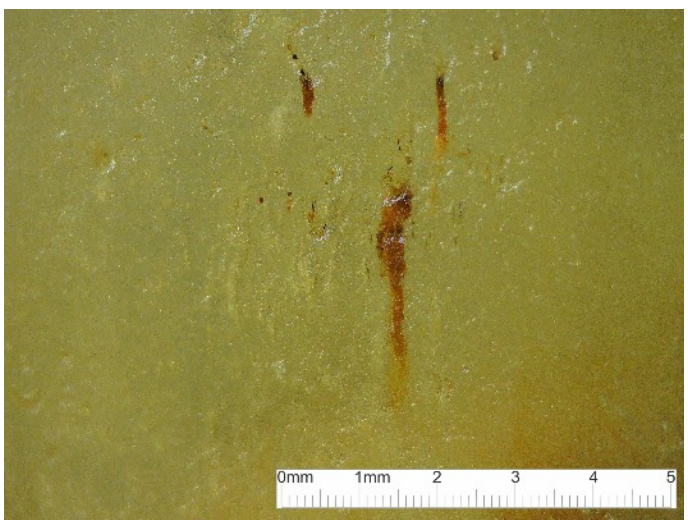
The entire item is shot through with embedded blurry structures. The image below is the B side, with the top being the emerging leaves. There are many small long pits on the surface that maintain the same alignment. The pits being filled with gunk helps pick them out. The buried structures seem to splay out slightly rather than stay parallel.

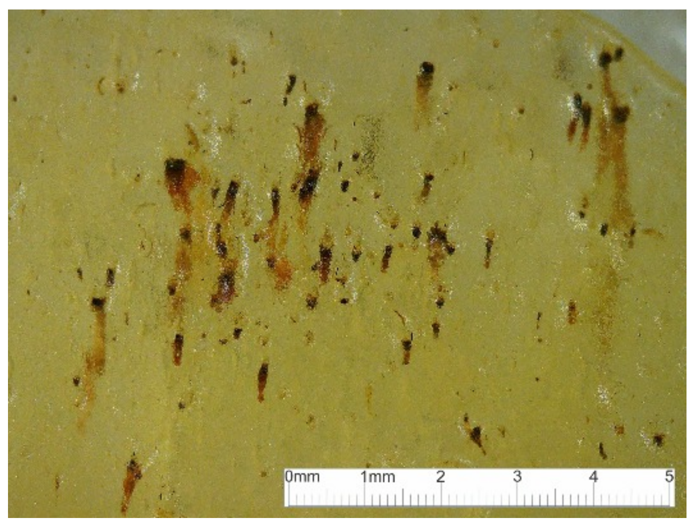


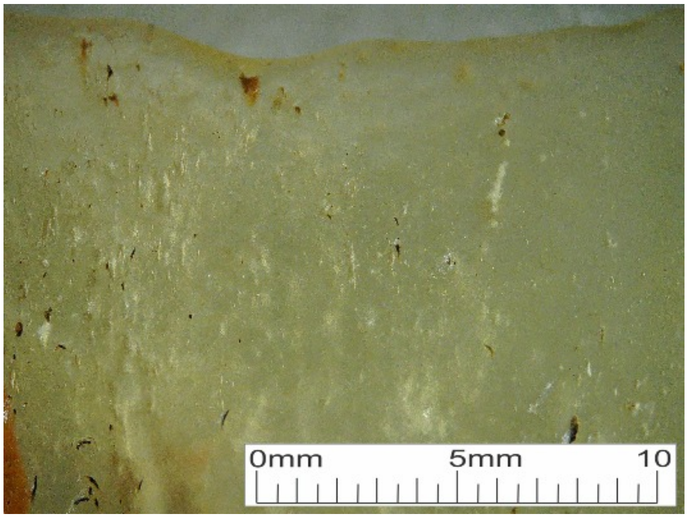


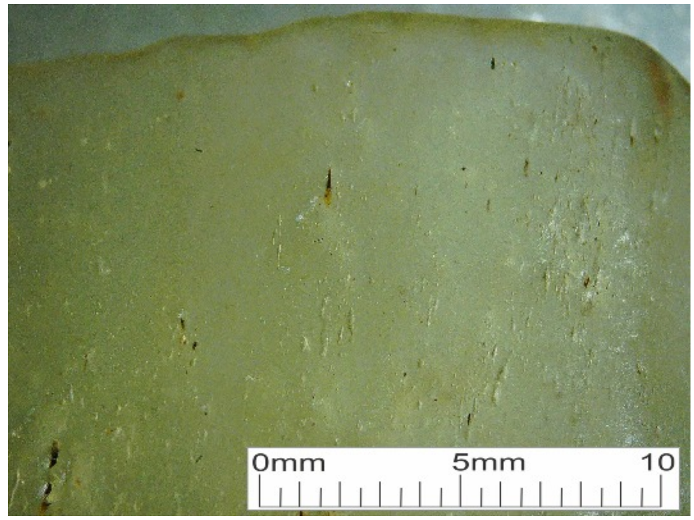
When backlit and seen from side B, the pits on the surface line up with strings of elongated bubbles. The gunk and the brown silt go only a little ways in, but something has left a trace right through the piece.

In normal lighting as below, the black gunk blocks the cavities, and the brown silt penetrates some distance. These images again are the B side, which means some filaments were rising out of the sand and angling in roughly the same direction as the leaves.



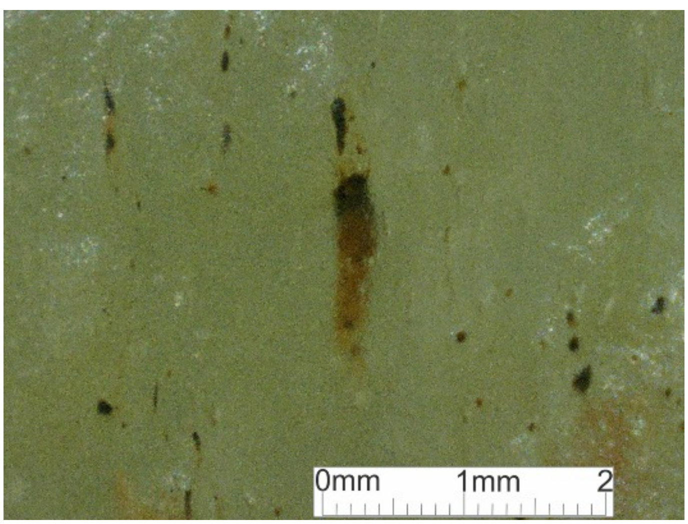


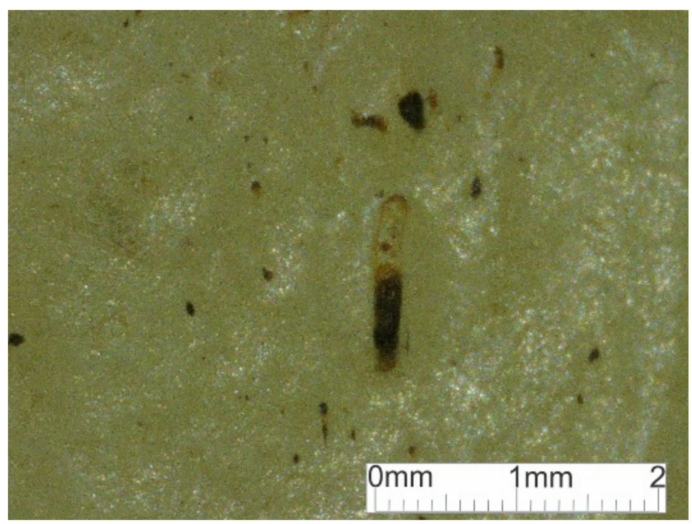




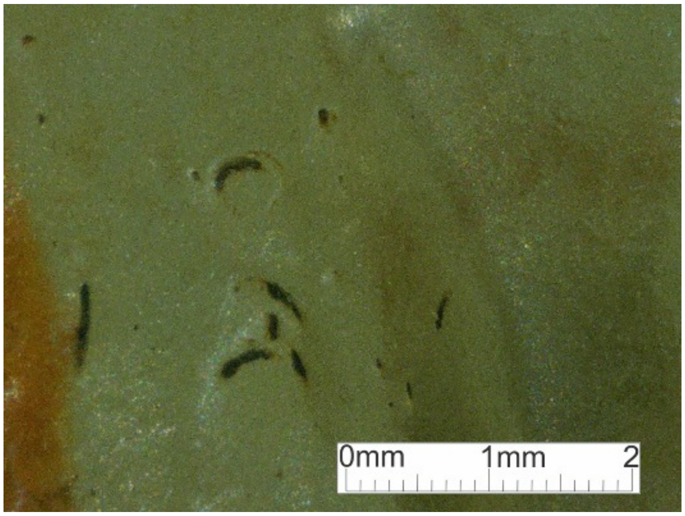
Small pits also appear on the A side above. This is in direct contact with the leaf. Almost none of these penetrate the body, but consist instead of shallow dents. Most are elongated along the axis of the leaf. The most reasonable interpretation of these pits is that we’re looking at casts of part of the leaf anatomy or perhaps something deposited by insects. All this was buried under sand before the formative event, of course.

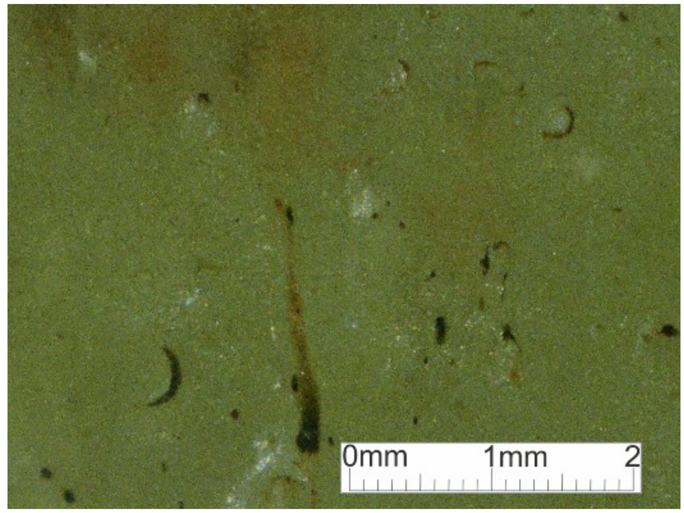
The same pits are shown below.



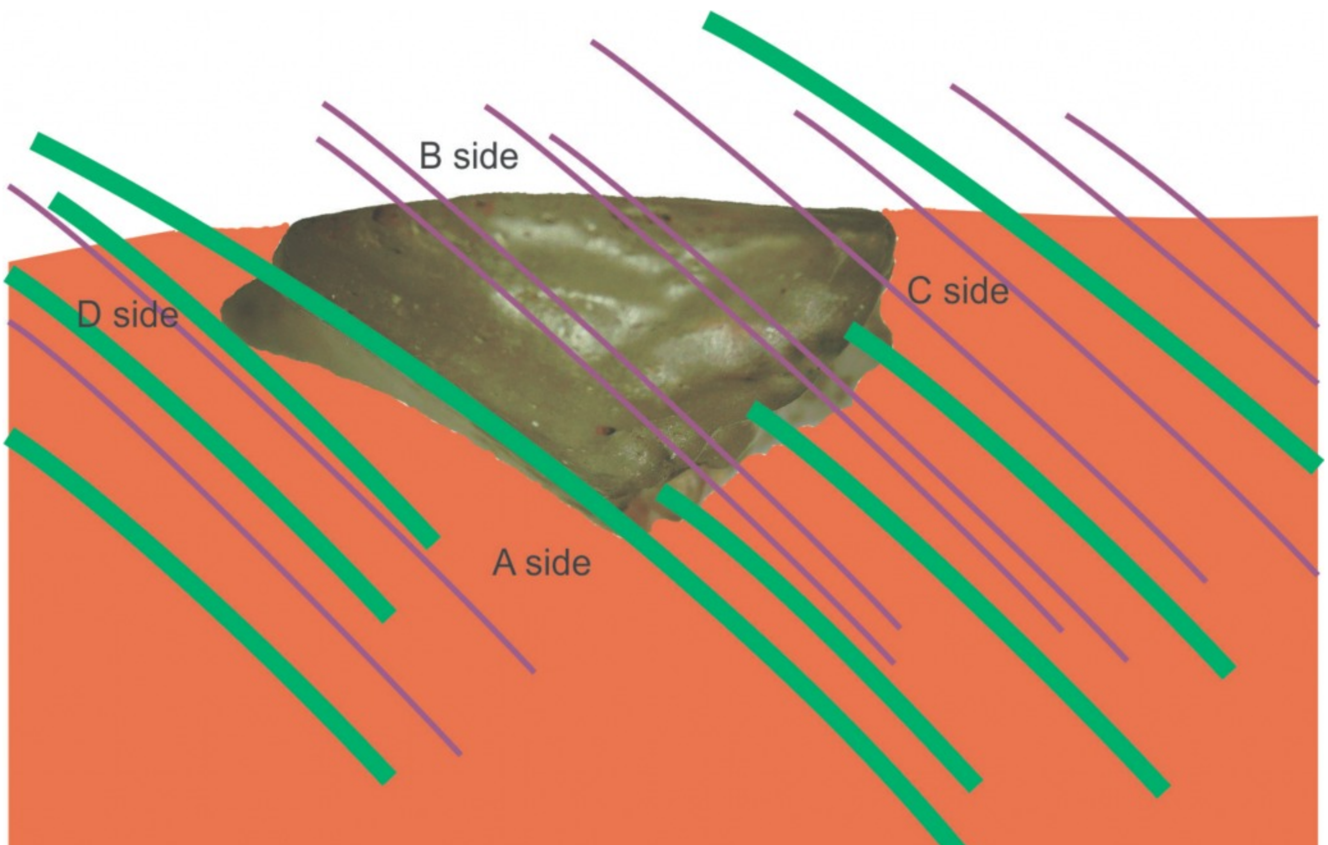


There are a very few circular scars on the A side as well. I have tentatively identified them as the ends of crystals. It seems remarkable that any threads were able to lay down in this environment, with all the obstacles on the dune surface, and aerial filaments to disturb or bleed off static charges.





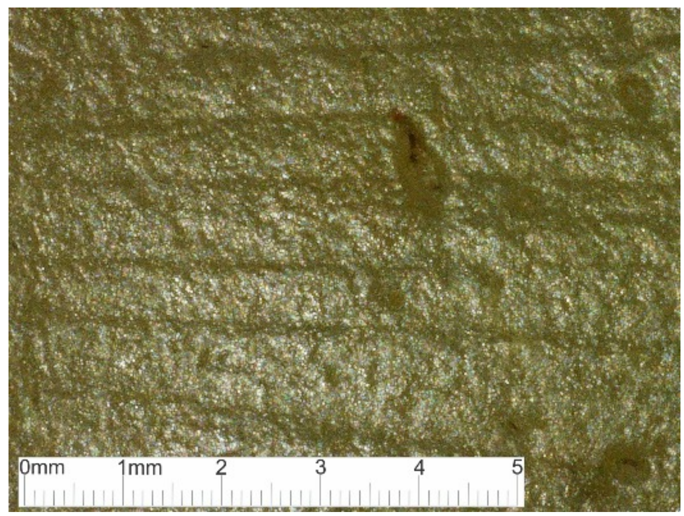
The developing picture is as in the image below. There was a broad-leaved bush with some finer filaments as part of it or growing up through it. Sand buried it perhaps more than once over its life. In this instance a slanting group of leaves happened to form a line on the left, and a series of twigs or sprouts was just short of breaking the surface. When the LDG formative event happened, the left-leaning leaf group formed a break, as did the shallow C side. There were probably many such divots for each half-buried bush.

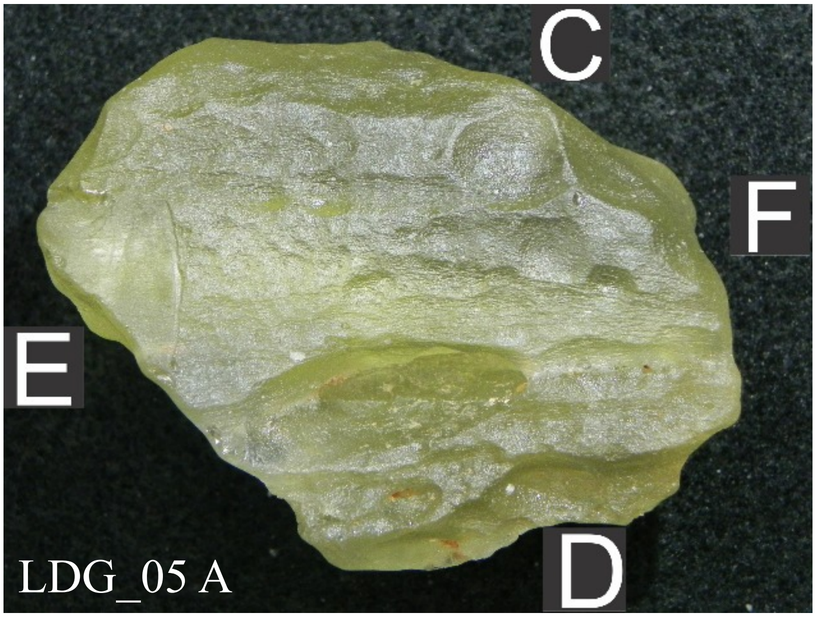


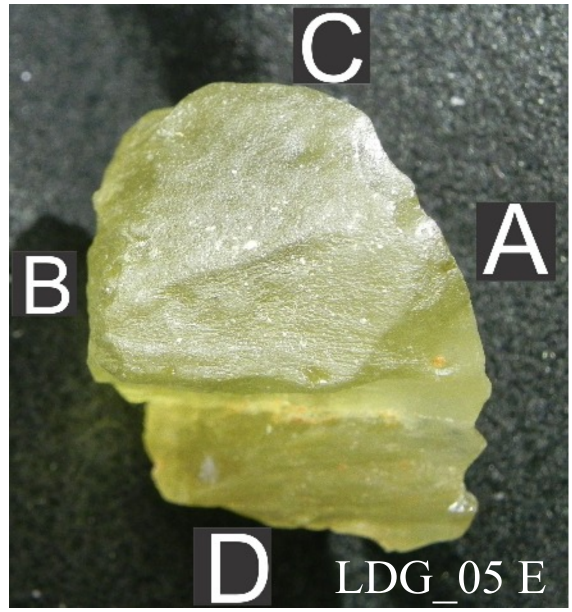
Any individual silted void might be explained as a fracture. But the entire assemblage of surface traces, penetrations and cavities makes sense only as the remains of a leafy bush or small plant nearly buried by sand. This is an unequivocal collection of leaf fossils. The preservation of leaf thickness expressed in the voids, agreeing with the implied thickness in what I termed step-downs of the exterior, argues that the leaves were not turned to ash in the event, nor was there enough shock to flatten them.

The delicacy of captured filaments also suggests the fluid silica was not viscous. Glass that is barely melted is the consistency of taffy, and when very hot is like honey. But these filaments are captured with almost no air around them, meaning that bubbles were able to exhaust nearly completely. And if there was any vertical compression of the melt, it didn't bend or kink the vertical filaments. The silica was very fluid.

A final puzzle presents on the B face. A series of nearly parallel scratches fans out from about the middle, ending at the corner between the D and E faces. The lines are straight, they don't look fresh, they never cross each other or seem to repeat in the same line. It doesn't look like wear from repetitive use as a scraper. These don't resemble the threaded crystals, but are spaced out incisions on a randomly micro-pitted surface. This stuff does not scratch easily, but these are clean and practised-looking cuts. I'm left wondering who did this, for what reason, and with what tool.



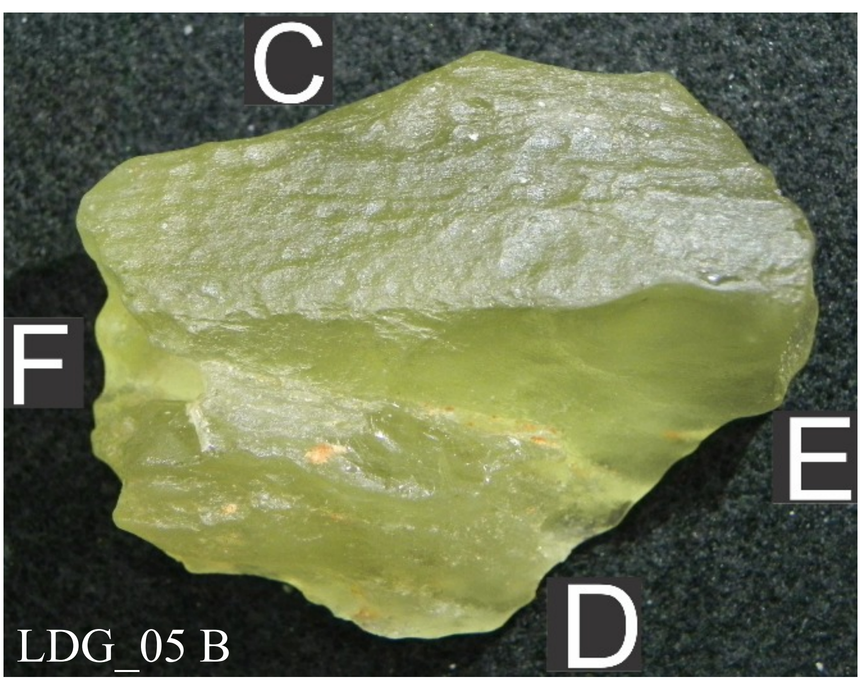


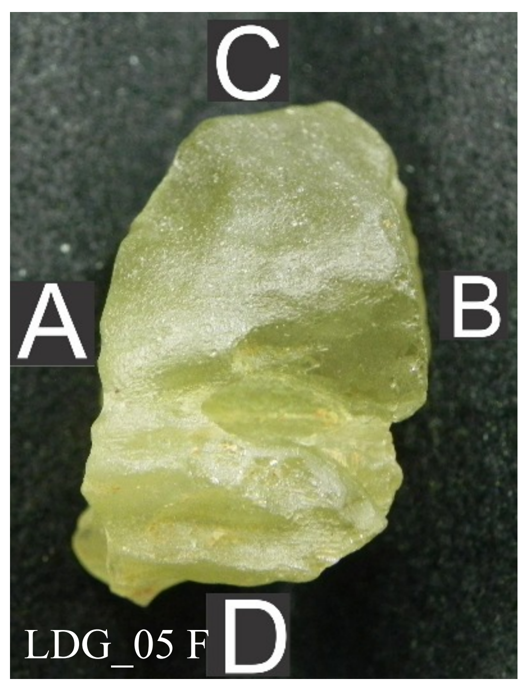


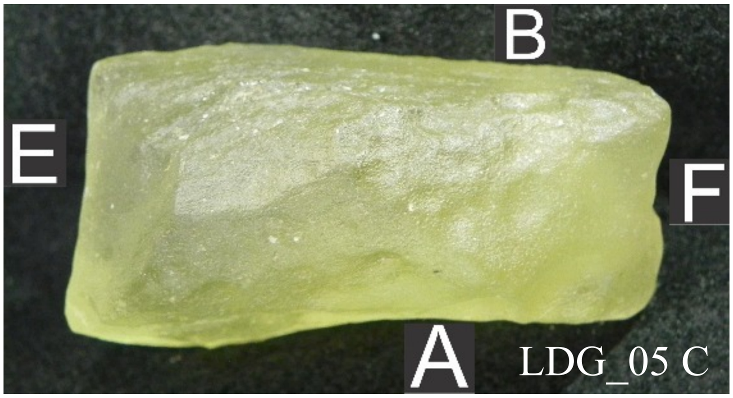
Sample 6 - LDG_05 - Embedded Seeds

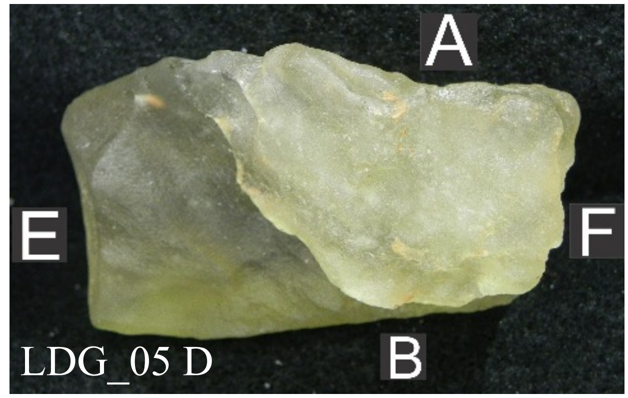
This item strongly supports my threaded crystal model, while providing good evidence for fossil casts of plant material. As in the prior sample, this one supports the radiation hypothesis by showing evidence that no significant shock can have been involved in the formative event.

This specimen is about 2.25" by 1.5" as viewing the A face, and about an inch thick. It consists of two bodies of green glass joined by a thin lighter region. The D side image looks lighter. Partly this is because the light-colored joining area shows through the green glass better there, and the body of glass on the D side is thinner, letting more light through. But the D side is also genuinely lighter with more internal light bands, indicating some change in the sand being laid down.



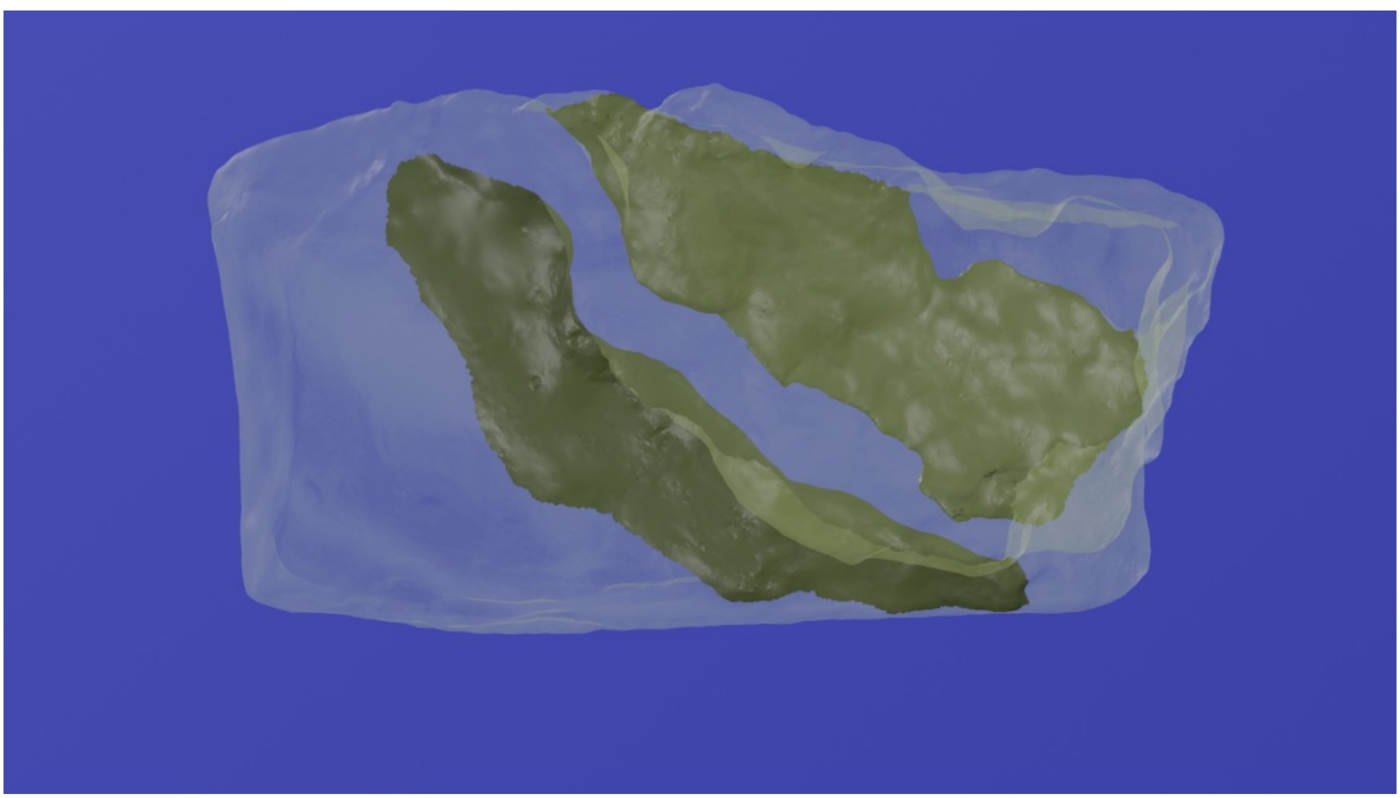


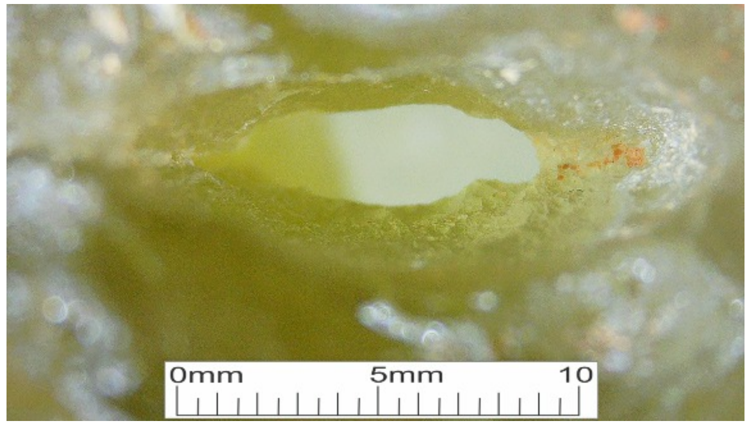




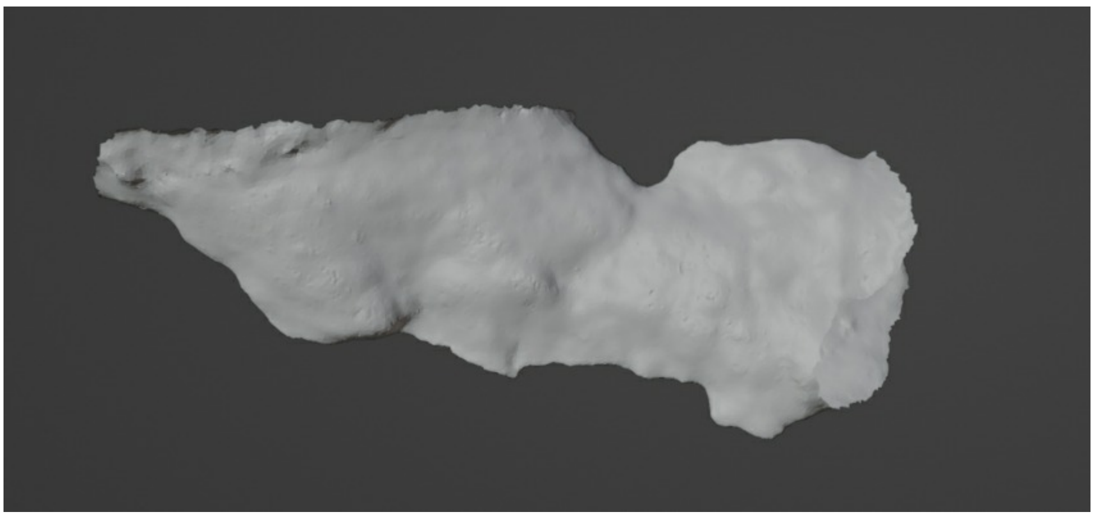
The joining region (and the glass above and below it) appears to contain casts of at least three seed pods, two of which make a hole right through it. These are intriguing but not by themselves conclusive. After subtracting the apparent casts, the cross section of remaining rock is a small portion of the overall joining region, resulting in two thin legs. That this vulnerable structure survived unbroken for thirty million years is striking. The joining region is approximately horizontal for the four images on the prior page.

To understand the specimen better, I used photogrammetry to make a 3D model of the exterior. I cast a silicon mold of the cavity and again used photogrammetry to make a model of the interior, and stitched them together. The image below is about same view as the D image above right. Two areas are picked out. The through-hole in the upper right quadrant is in black. The exterior region that appears to have a seed impression going from upper left to lower right is in black, partly obscured by an overhang that here lightens it. A large portion of the overhang (the lower-right two thirds) shows a glossy break. The undulating clear band from upper left to lower right, and the small clear island at top right, are the only points where the two parts of the specimen are connected.

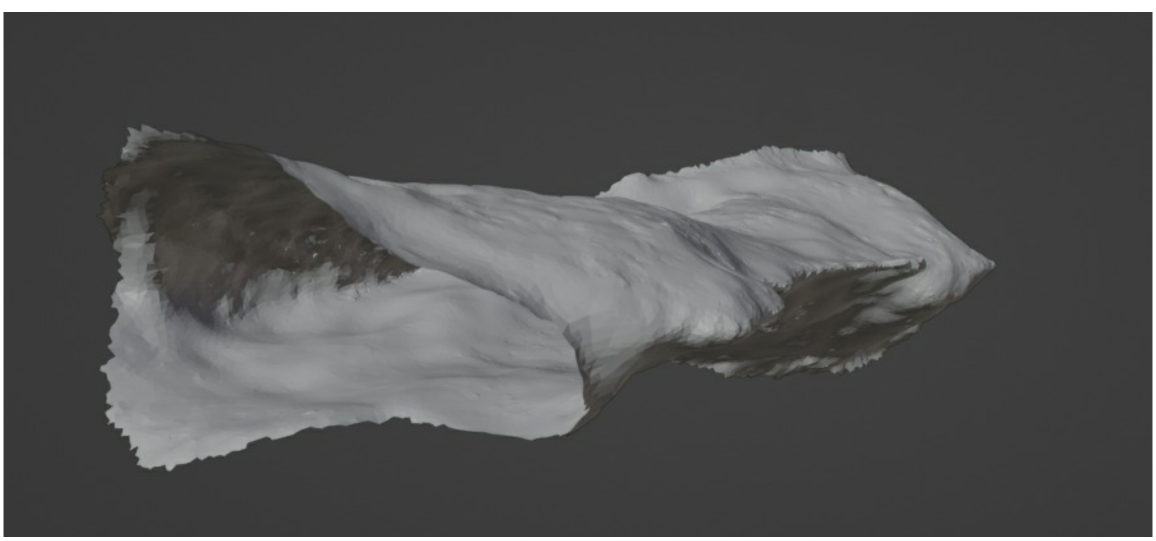


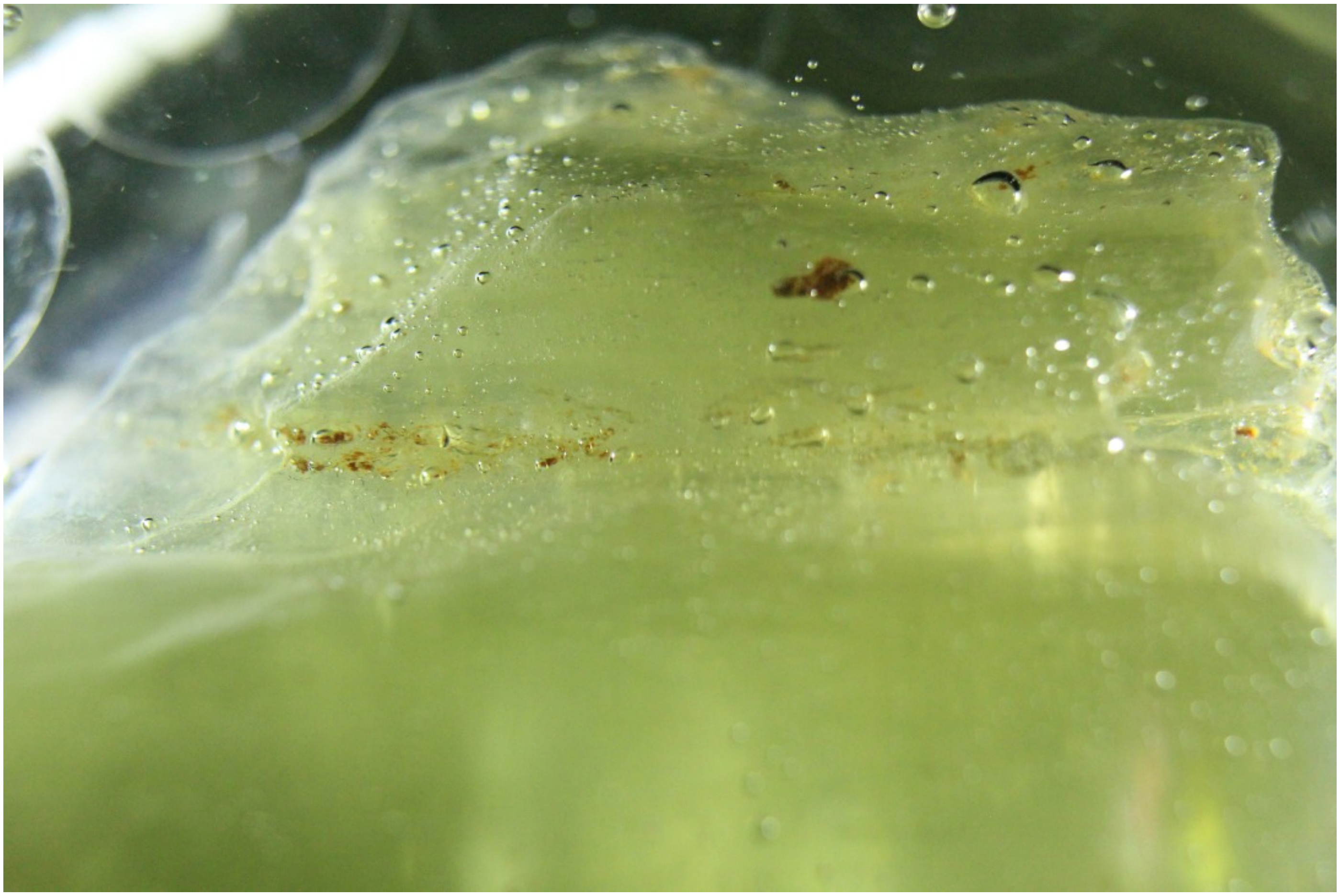


The images above show the through-hole from the F end (left) and the A side (right). They look plausible as seed outlines. The image below shows the hole with the rock removed. While the left part of the cavity is fairly smooth, the right part seems more irregular and pitted.



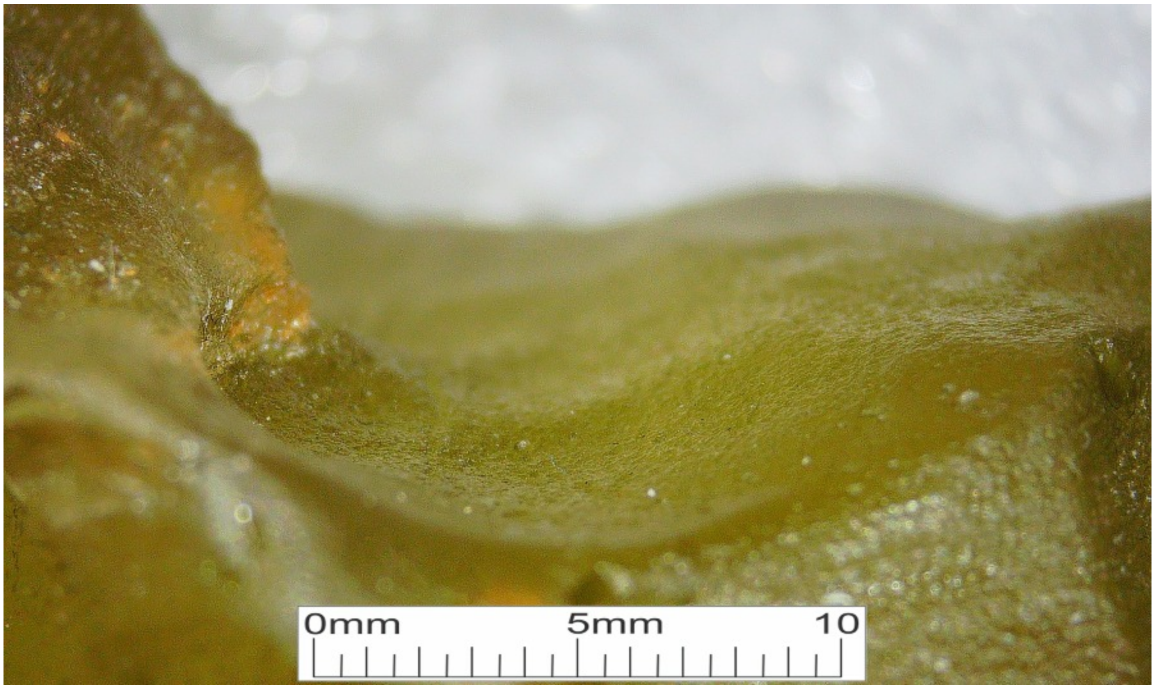
Viewed along the plane of the central cavity's side, the irregularity seems limited to the extreme edge. This corresponds to the horizon of the whole piece, and specifically the lighter boundary material connecting the major parts.





The joining area is seen here in a Karo bath, viewed along its horizon. The D side (here on top) is genuinely lighter, with whiter bands. The joining area stands out for the number of small cavities and a minor change in coloration. The cavities may be the remains of plant debris, and the whole suggests a shift in the blown sand chemistry, and perhaps a pause.

In this view, the flattened edge of the central cavity (on the prior page) is probably the remains of fragile plant material associated with seeds, sepals perhaps, which may have lain exposed on the dune surface for some time and there became flattened and degraded. More sand then layered over it.



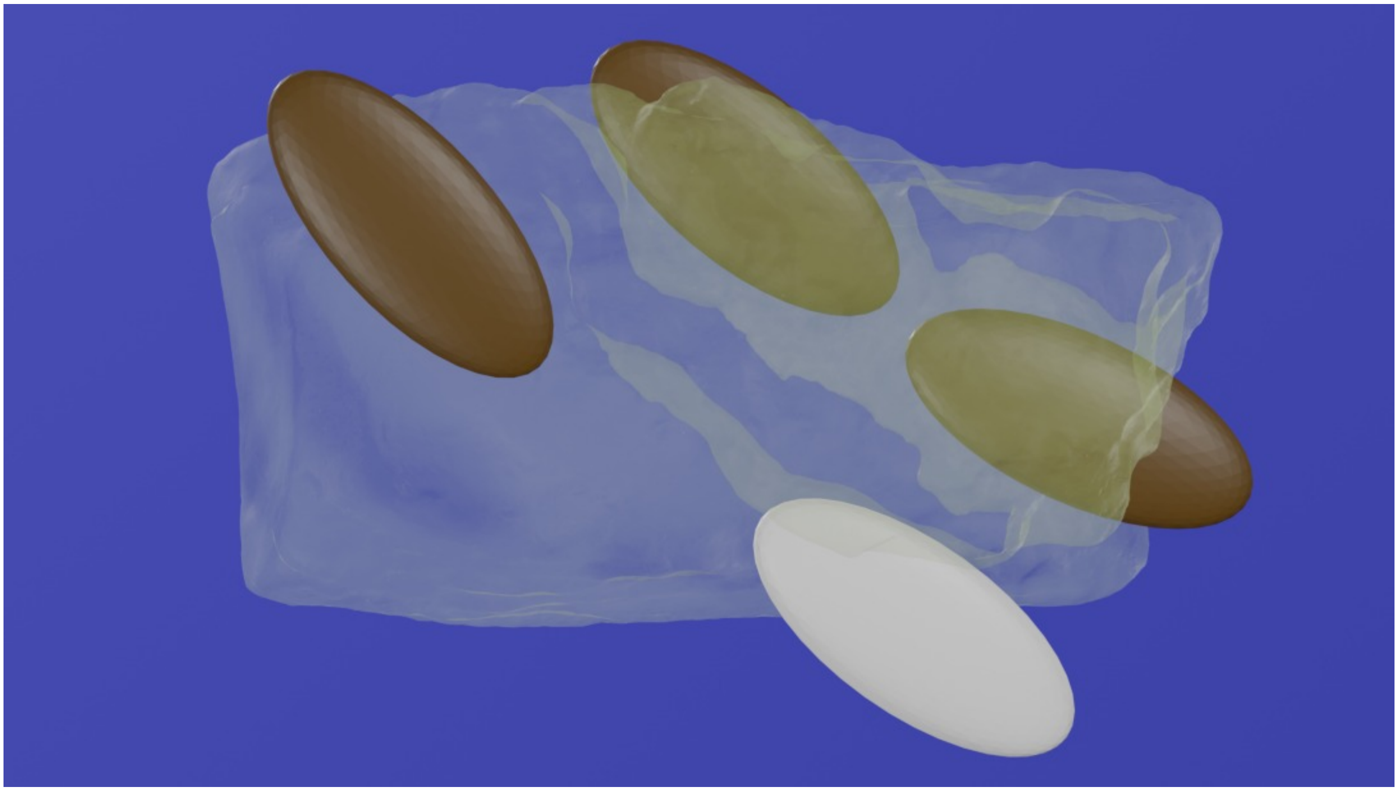
The image above is the D side (up) taken from the E end, showing the large pocket corresponding to one end of the through-hole. The broken overhang starts on the left beyond the end of this pocket.

The image below is again the D side taken from the F end. The overhang starts at the right end of the scale, and the fracture begins about 13mm on the scale. The bump at about the 8mm mark might have been the contact point, if the overhang marks a hole symmetrical with the existing one.

There seem to be three possible sources for the cavities: They might result from chemical etching, they might be casts of some mineral, or they might be casts of seed pods.

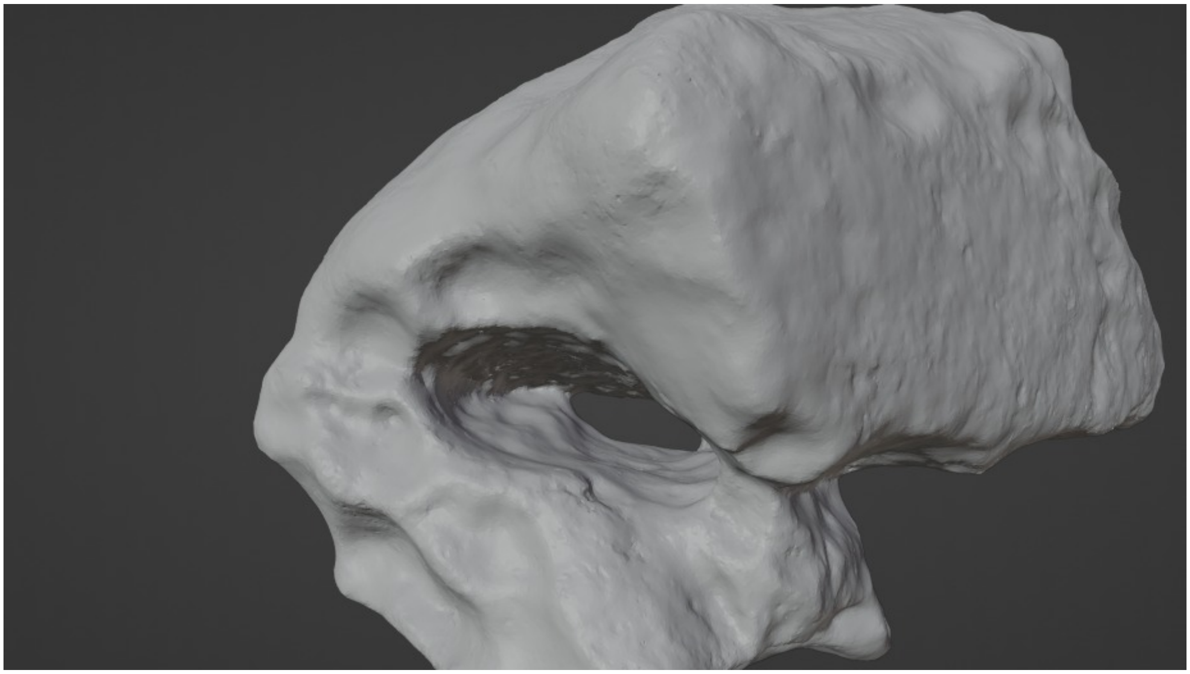
Much of the lighter joining band is recessed (or has an overhang, depending on how we interpret it), but the A and B images above show this area at the F end and there is no apparent preferential etching. The through-cavity shows a considerable material loss above and below the joining band, so it’s not simply that the band itself is chemically vulnerable. But the undercuts and material absence are clearly centered on the whitish joining region.

The cavities might be from some mineral that dissolved after the formative event. The precursor site is described as consisting of sandstone, sand and quartz. I can’t rule out some soluble mineral, and can’t guess what it might have been. The fortuitous alignment of blobs of such mineral seems highly suspect.

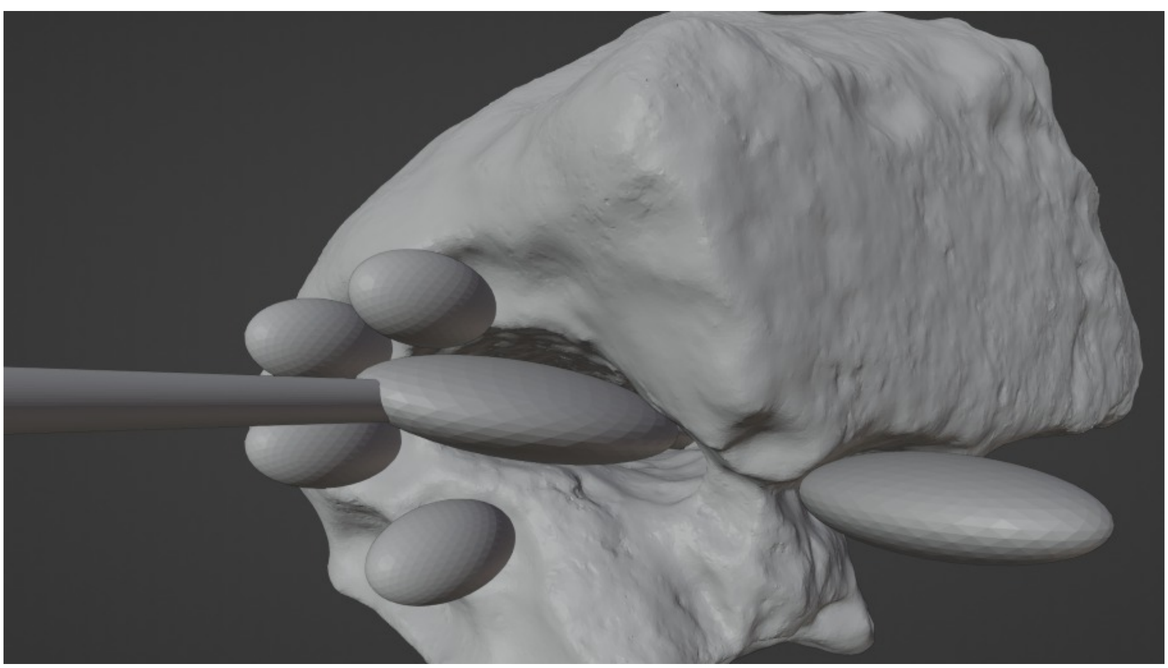


The above image (viewed from the D side) uses a proposed seed shape to fill in the through-hole and the curved pocket near the E end. Seeds are 2cm long, flattened ellipses, and fit without impinging on the rock surfaces. The shape of the seeds in the hole is roughly set by the hole itself, and a matching seed size and shape fits the exterior pocket at the left. The white seed has only a trace of a pocket and the now-missing overhang to suggest it might have been there.

Supporting the concept of these holes being organic, there are four dents circling the hole opening on the F end. Part of the opening is broken away, so the circle is not complete. It appears two or three more could fit in the missing part. Due to coloration changes, this images better in the 3D model. The upper image below shows the plain hole, and the lower shows small solids socketed in them to better show alignment. The tell-tales define a plane, and this suggests how a stalk might have lined up.

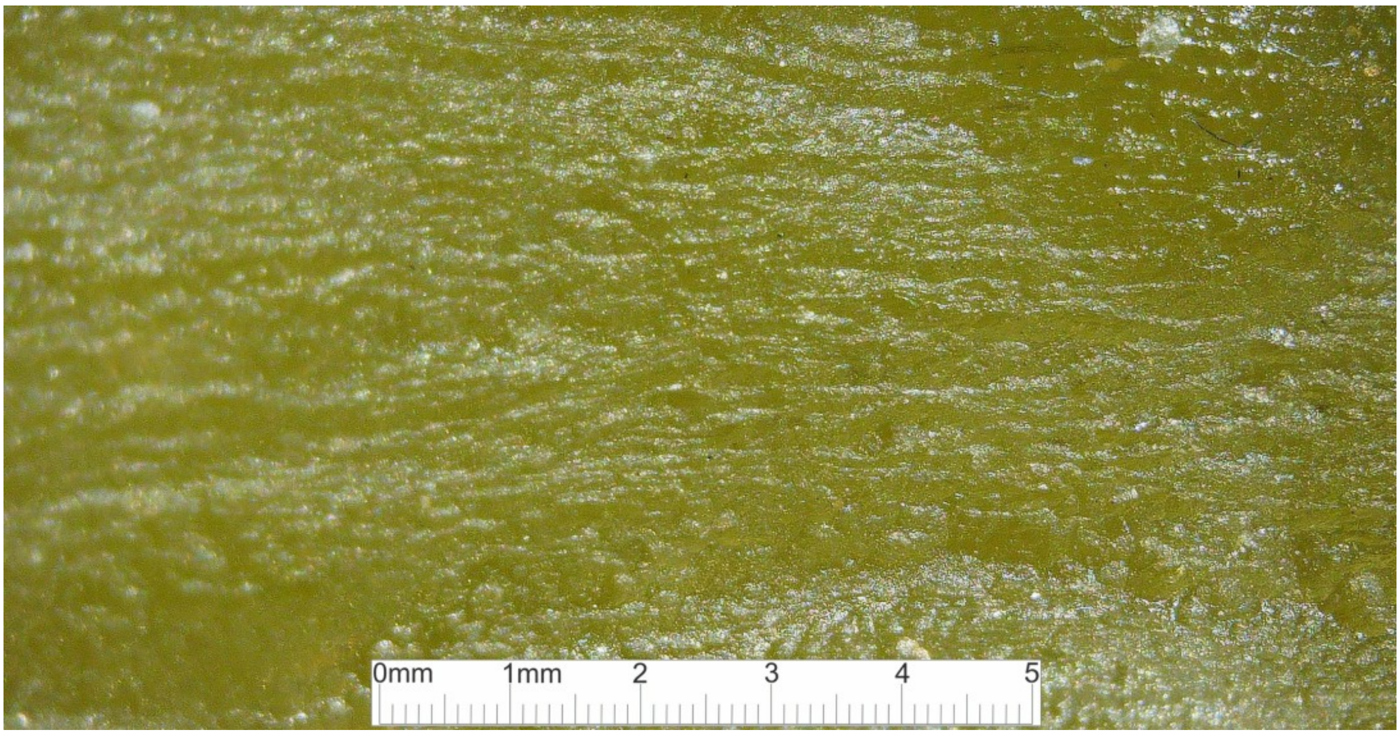


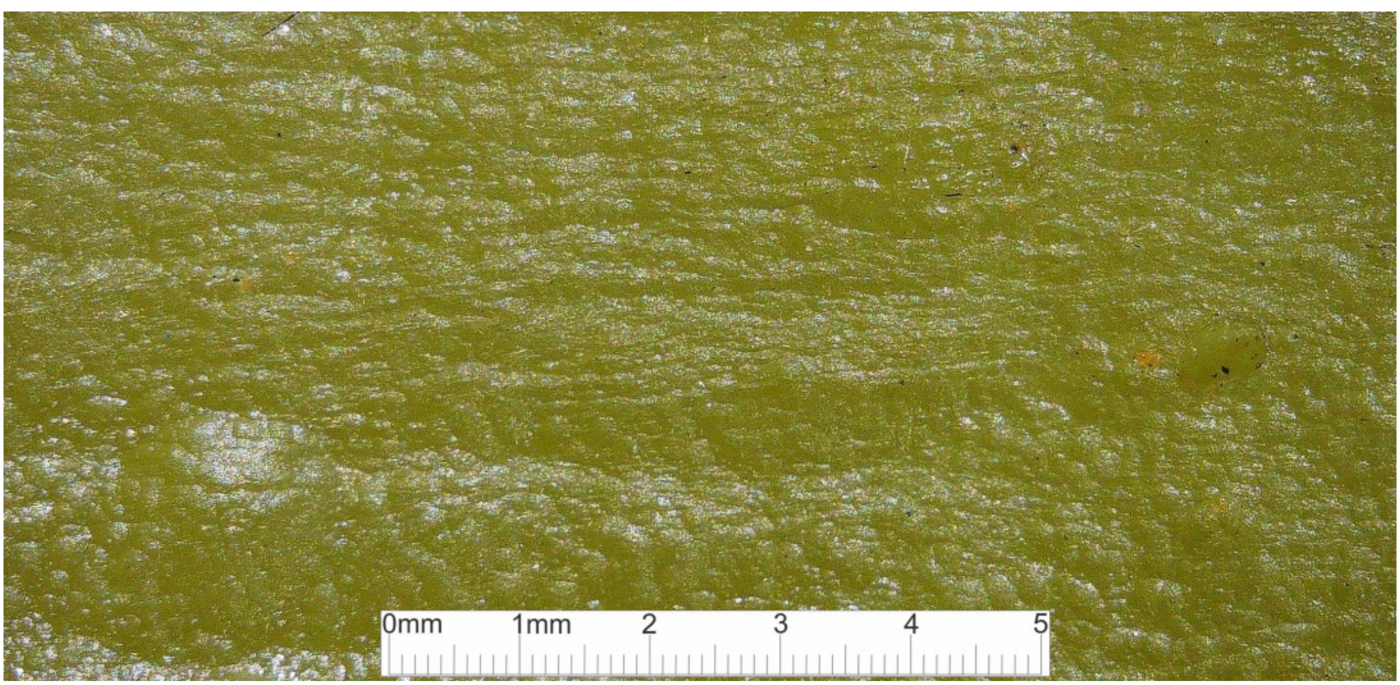
These might have been buds coming off the stalk, or the base of a structure supporting the seed pod. I'm not guessing what this plant looked like or how the biology worked. But the ring of dents and their alignment suggest that there's something organized going on, and I propose it looks like biology.

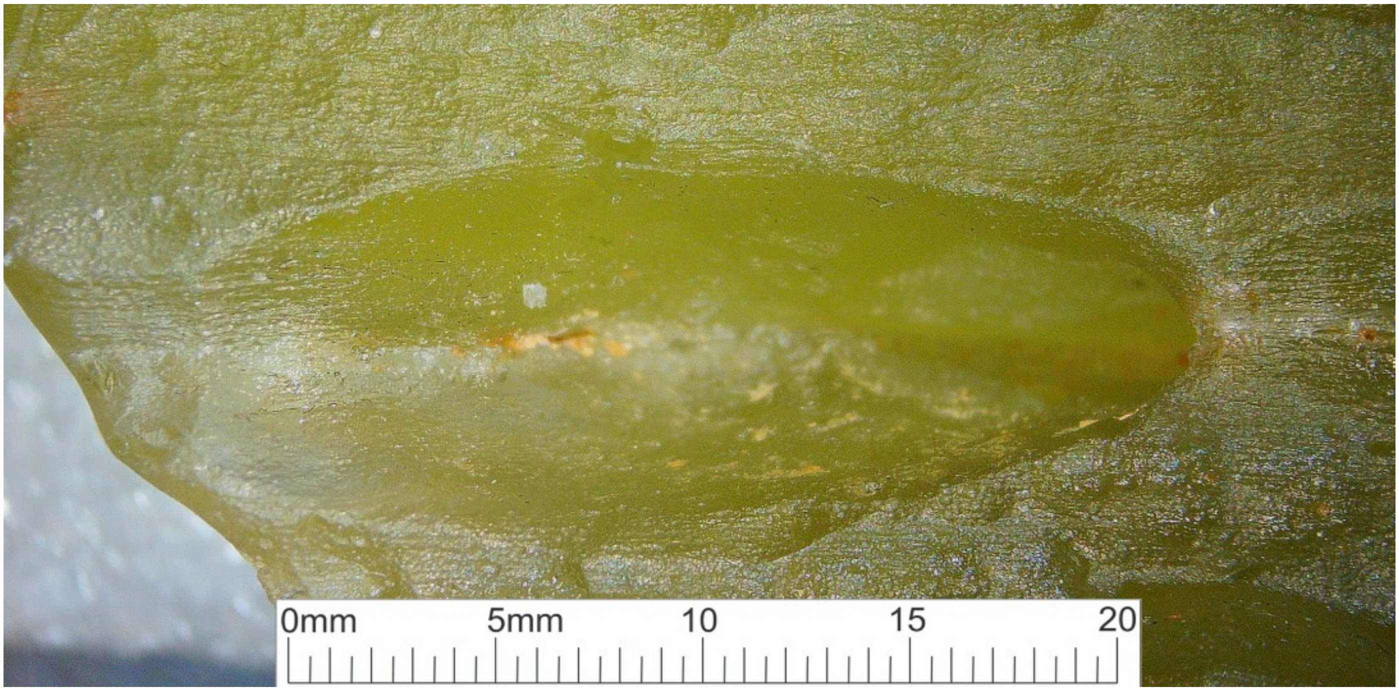


This sample shows the most pronounced side-view striations of my collection. Sample LDG_03 showed clear striations on its D side, including apparent crystals following the curve of the supposed surface. But that sample was most notable for the top and bottom surfaces covered in striations. Sample LDG_10 showed apparent crystals covering the entire original surface, with less on the sloped knapped sides. But this sample fractured in line with the apparent crystals, leaving both the A and B sides covered in long lines. This seems to suggest the crystals are a nontrivial strength factor in the glass.

The top image below is side A, the bottom is side B. Both sides have shallow pockmarks, but the striations can still be seen on the flatter bottoms of those pits. The sides slopes are shallow enough to not fully obscure the lines.

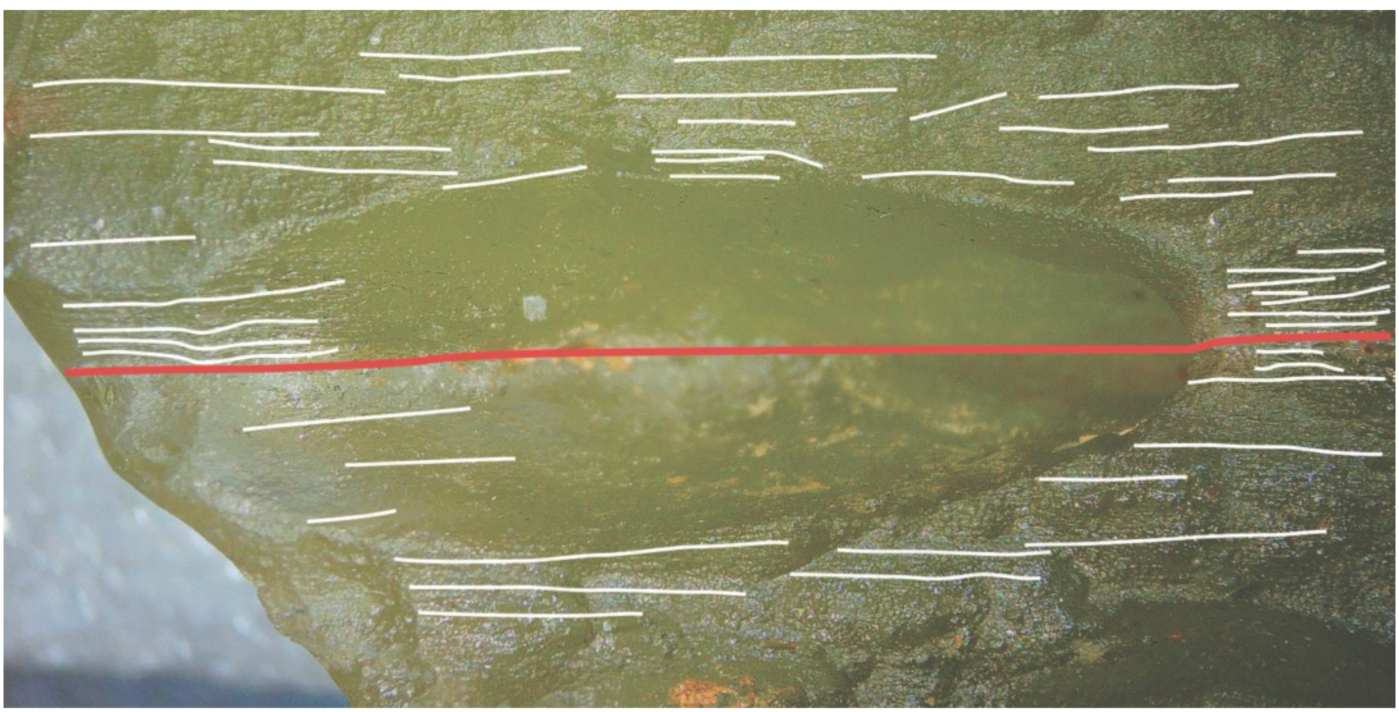






This is the first time we consider the sand void ratio - the space which is not sand. A typical void ratio for sand with mixed particle sizes is 0.3 to 0.4. We can presume the same ratio for my prior samples here without doing violence to any of my descriptions. If a column of sand melts, the basic compression mode is that the column vertically scales downward accordion fashion to 60% to 70% of its original height.

The image above is the opening on the A face, with striations visible all around it. Below is the same image with some striations picked out in white, and the separation band in red. The opening as seen from above is a diagonal cut across the postulated seed pod, but the opening also has some flare, so it’s probably still a reasonable approximation of the cross-section as seen straight through the hole.



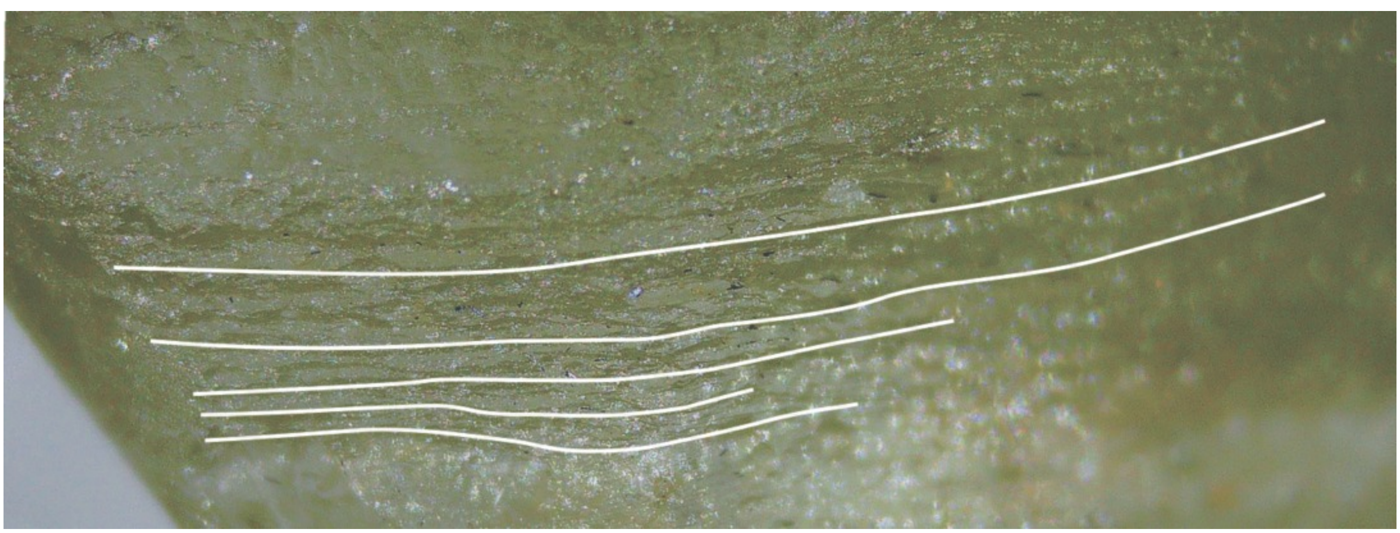
The threads make sense for a seed or other objects being covered by sand. The sand being deposited would not drape over the object like cloth, but would cover the ground in roughly level increments, growing up around the objects until it covered them.

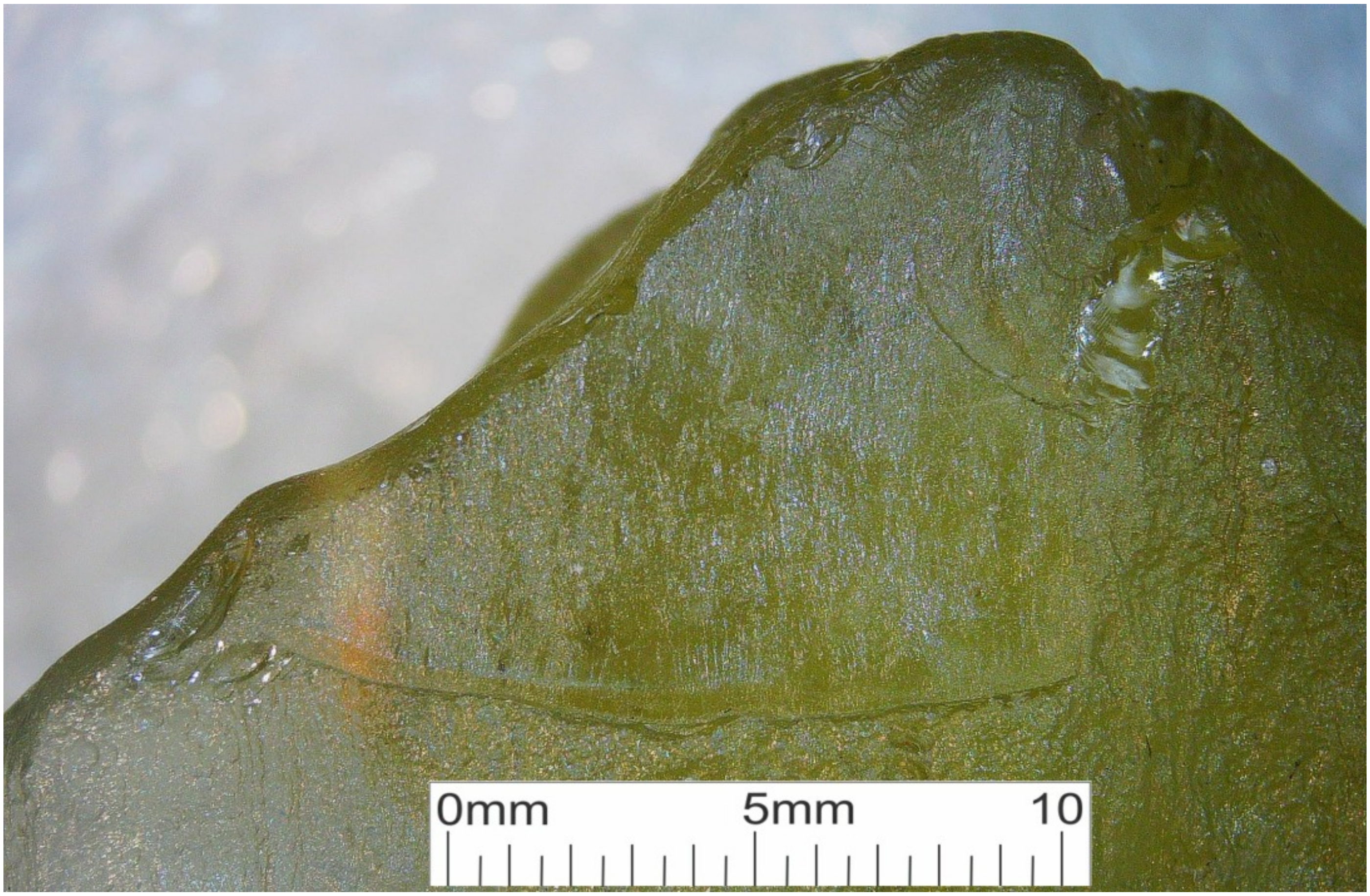
If the sand column melted, it would have lost about a third of its height, and the void space air would presumably have exhausted downward. Notable here is the lack of any perceptible distortion in the grain above or below the hole on this face. If the seed/charcoal were softer than the glass, it should be relatively compressed and the striations above and below the hole should deflect toward it. If harder, the striations should wrap around it as the sand compressed. But here the sand seems indifferent, suggesting the seed enclosed bodies roughly match the viscosity of the melt, if it were a melt.

If the formative event involved the top surface silica liquefying and wetting down through the column, the column would not collapse, and the horizontal threads would be preserved. If LDG were formed by a meteorite shock or air burst, this doesn't seem like a reasonable model. But if it were formed by a beta radiation event, this would explain why the LDG_05 column is not compressed. An open question is how viscous fluidized silica becomes in a beta radiation event, and whether it is variable along a spectrum depending on the radiation level. In other words, we need a beta radiation liquefaction and wetting model for silica.

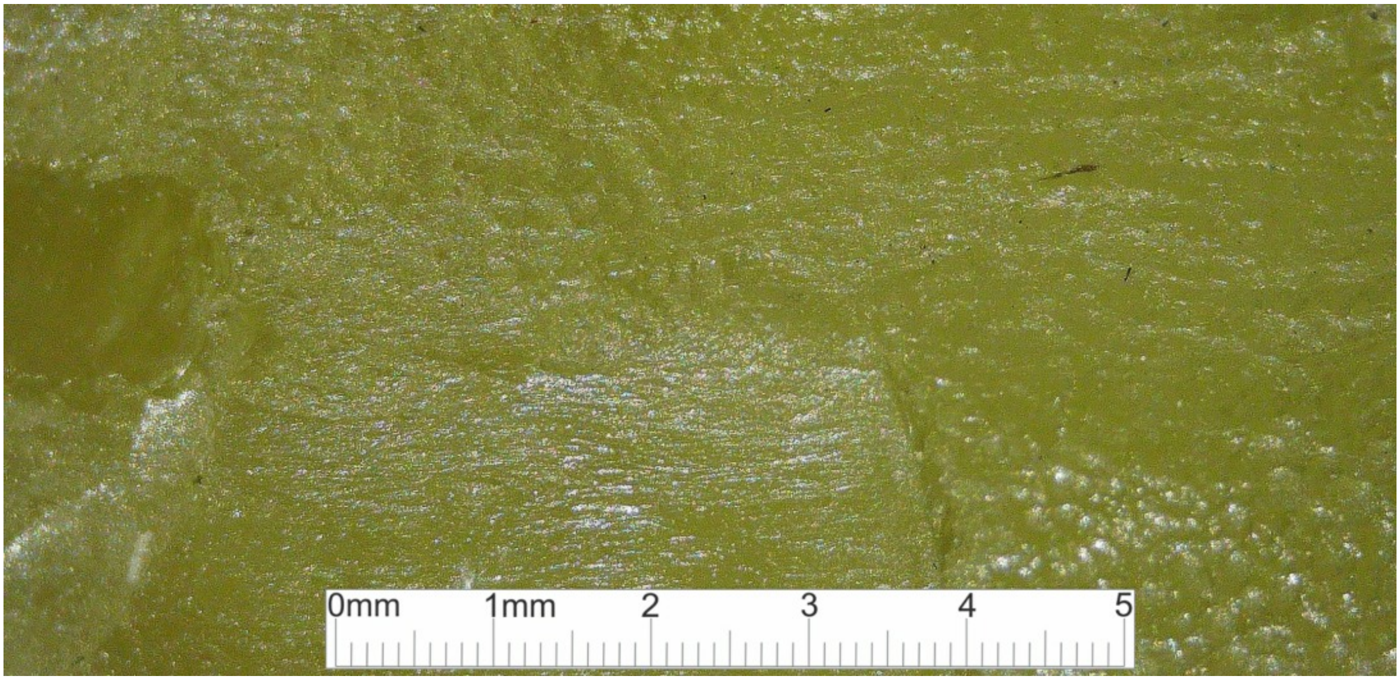
There is an interesting wrinkle at the left edge of the hole, highlighted below. Again the separation zone is held horizontal, and the grain rises slightly to the right as the lines turn to follow the inner face of the hole. Just at the edge of the hole seems to be a pronounced dip. If my model is valid, these threads must grow toward the oncoming breeze, which here must be from the right or left. If the prevailing breeze were from the left, this would be the place to find a scour, and these lines appear to sketch it.

If this is scour, then there was something filling what is now the through-hole, whether a seed pod or a lump of some substance more soluble than the silica glass.

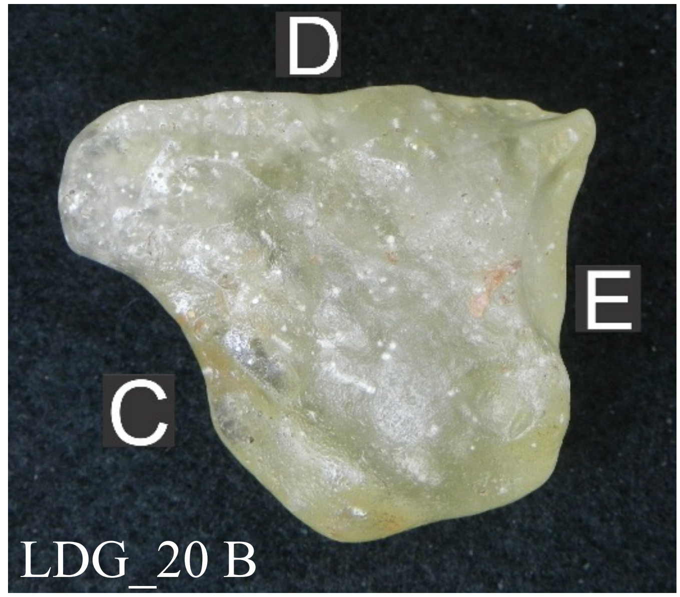




The final view of striation is this flake on the A side left edge. The break was once glossy, but etching has now started to bring out the striations as a thin imitation of those visible to right and left of the scale. At the top right of this break is a genuinely fresh and glossy conchoidal fracture for comparison.



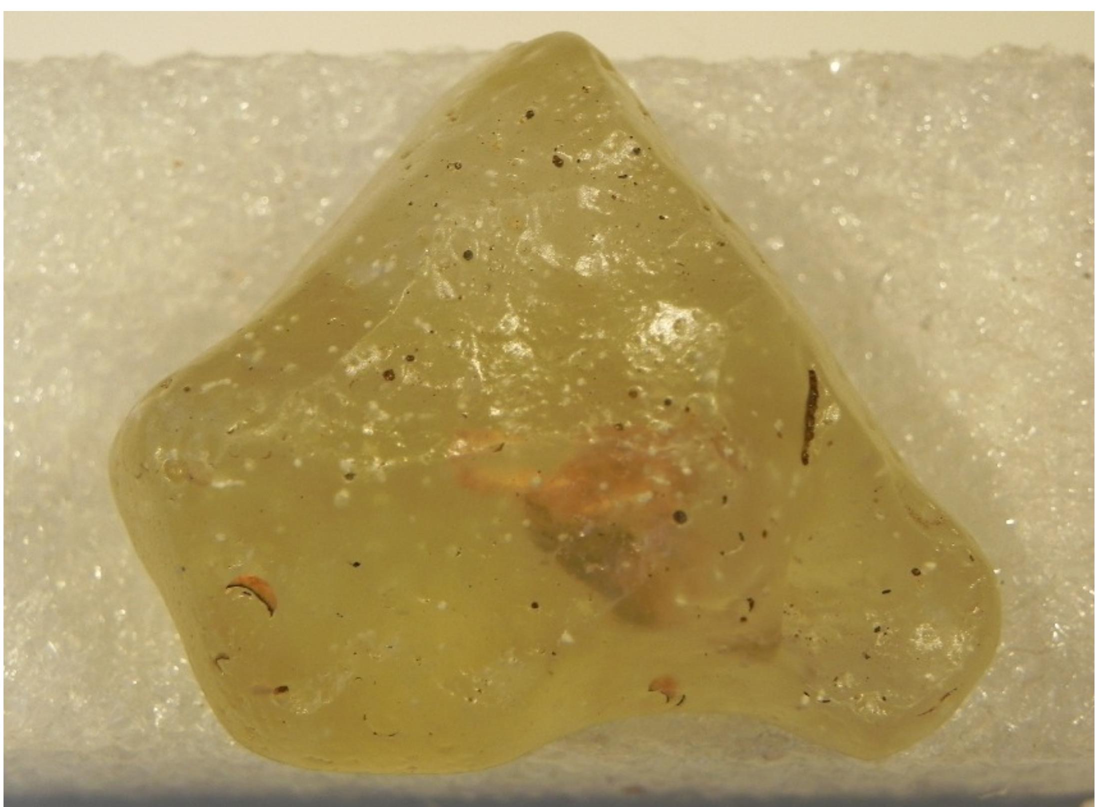
The close-up shows the new flaked surface in the lower and left quadrant, and the older striations in the top. On a flat surface, fine striations show individually. After the face acquires some wear, ridges and troughs develop, and fine striations are lost in the coarser landscape. But the new threads follow the alignment of the old. Wherever they turn up, striations consistently appear as weathering uncovering an internal structure, rather than detail being applied by an external agent.

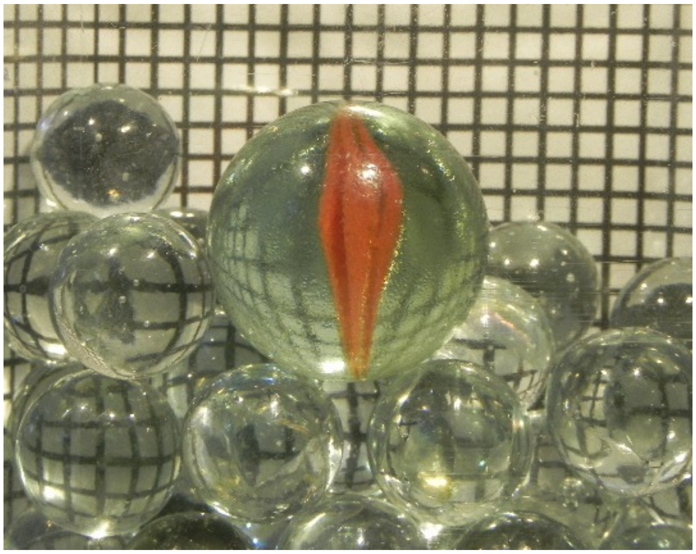
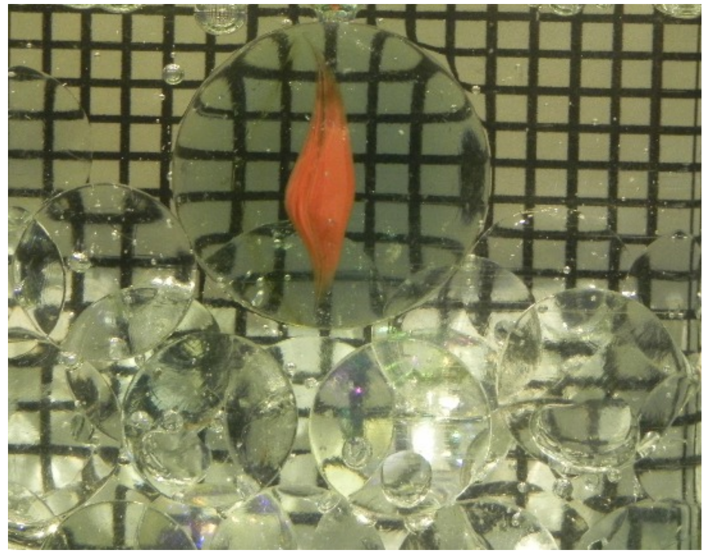


Sample 7 - LDG_20 - Seed Pod

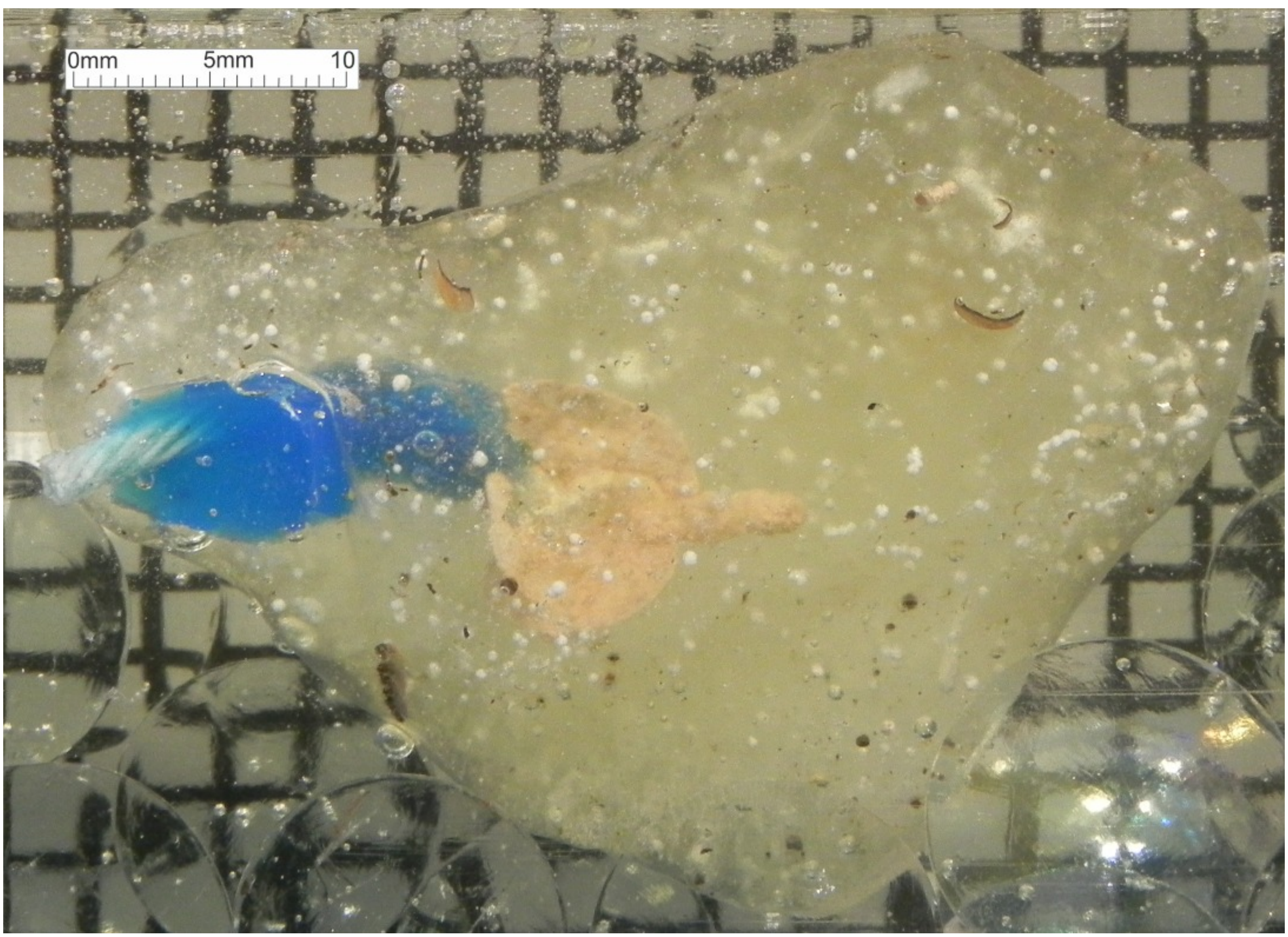
This specimen has a remarkable fossil of a seed pair and its surrounding husk. The labyrinthine path to the fossil's extreme end suggests it contains some original biological material, and the preservation of delicate structure argues that no high temperature could have been involved. This sample shows no striations.

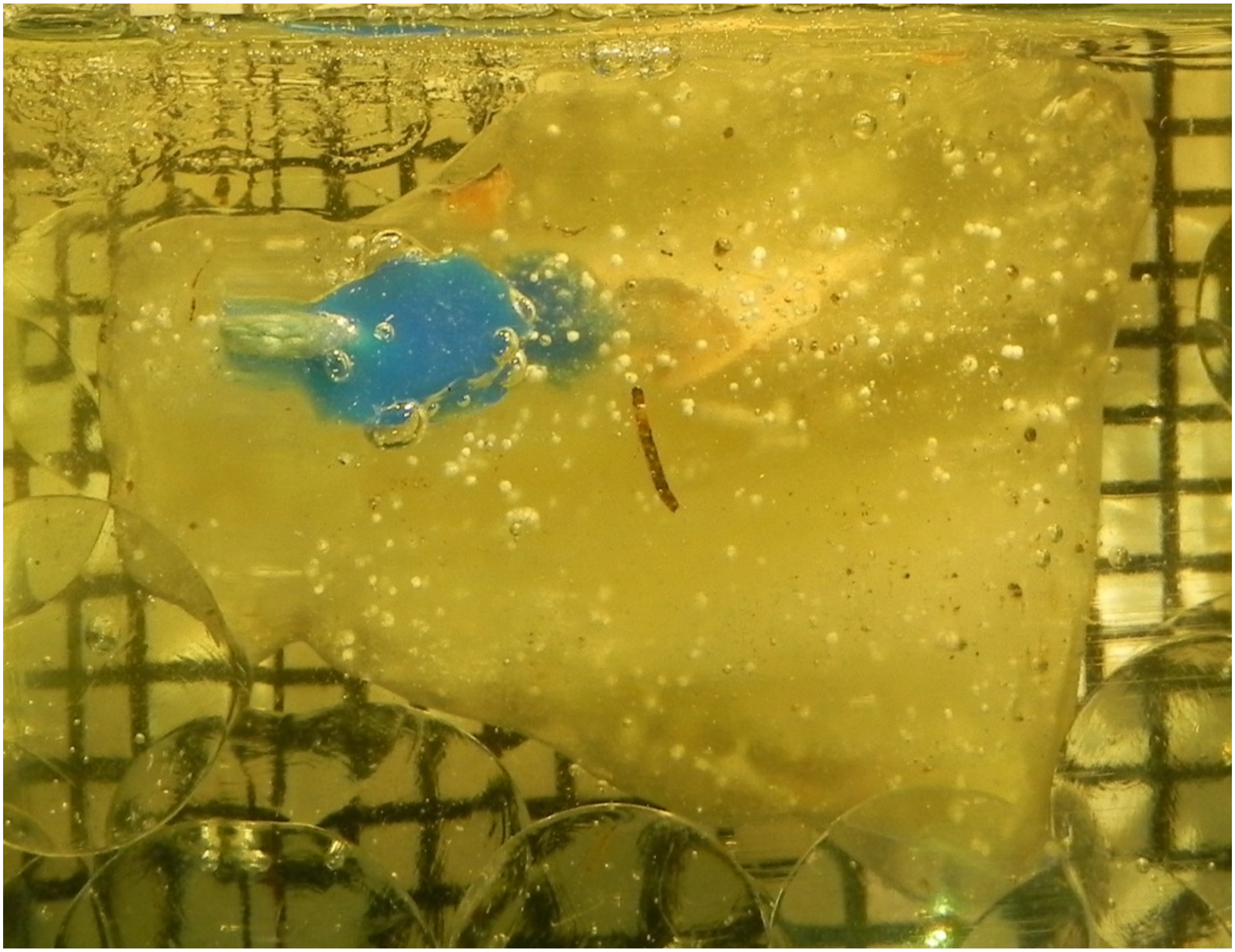
The piece is very roughly triangular, about two inches on each of the three sides. In the A image above left, the top left corner is a solid opaque mass. The contours and rough surface make it difficult to see the dark patch. With some lighting changes as below, the dark patch is clearer. It is close to the surface on the C side.



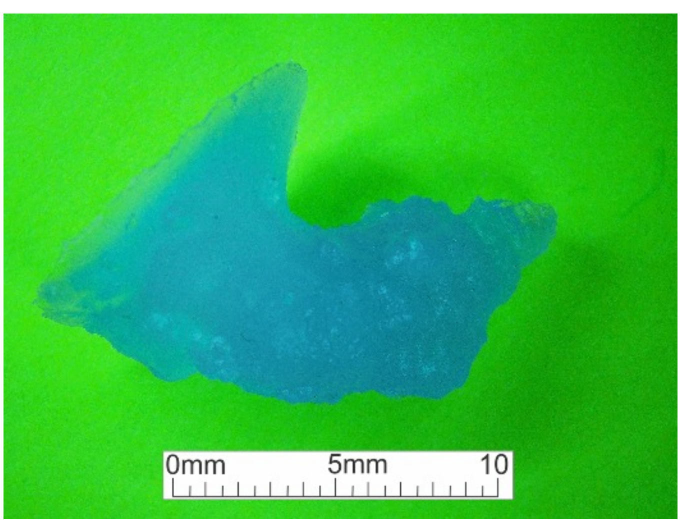



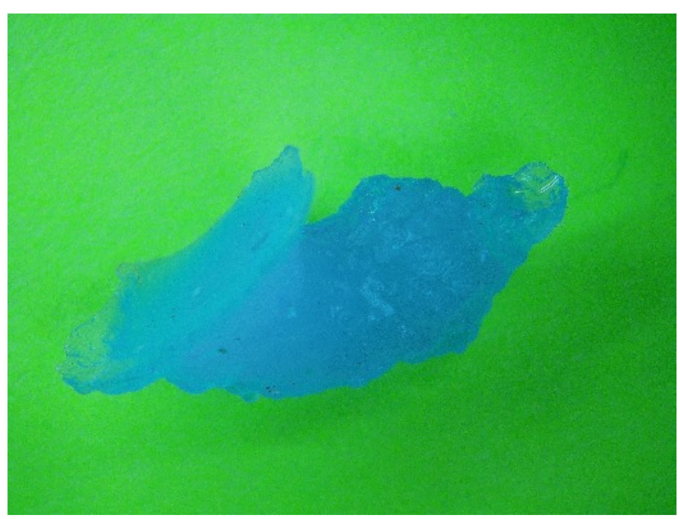
I set up a Super KaroVision bath to minimize the effect of refraction and the rough surface. A test with clear marbles is shown above, with a dry container on the left and Karo added on the right. The reference grid is much better fidelity in the syrup bath, and the cat-eye seems undistorted. I cast a blue silicon plug in the opening, to help distinguish it, and duplicated the Karo bath below with the sample resting on clear marbles.



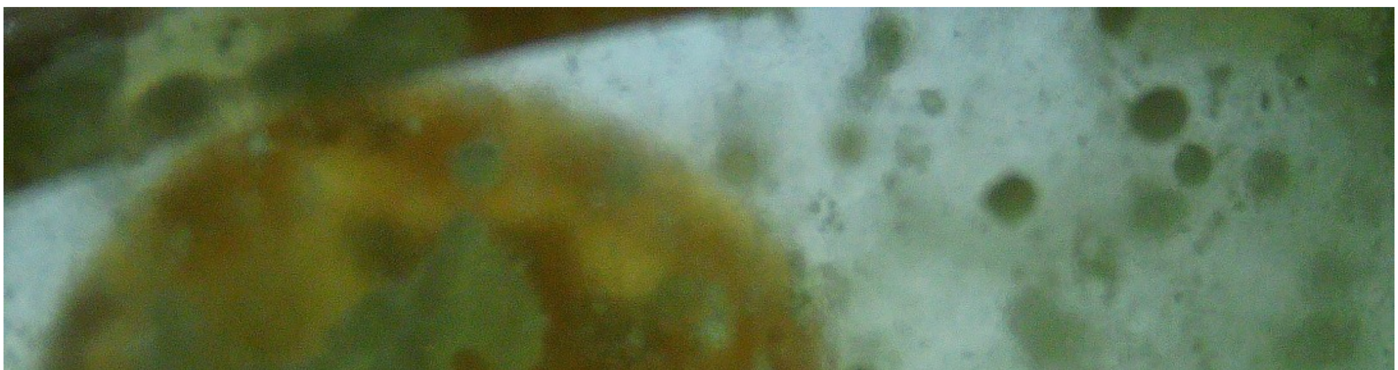


Rotating the specimen gives a view into the object. The first image looked like a flat seed envelope, but the view above looks like a pocket that partly contained two seeds. The seed cast is below. The seed appears to be grossly round in cross section, curved something like a kidney bean, with pronounced lumps at the inner end.





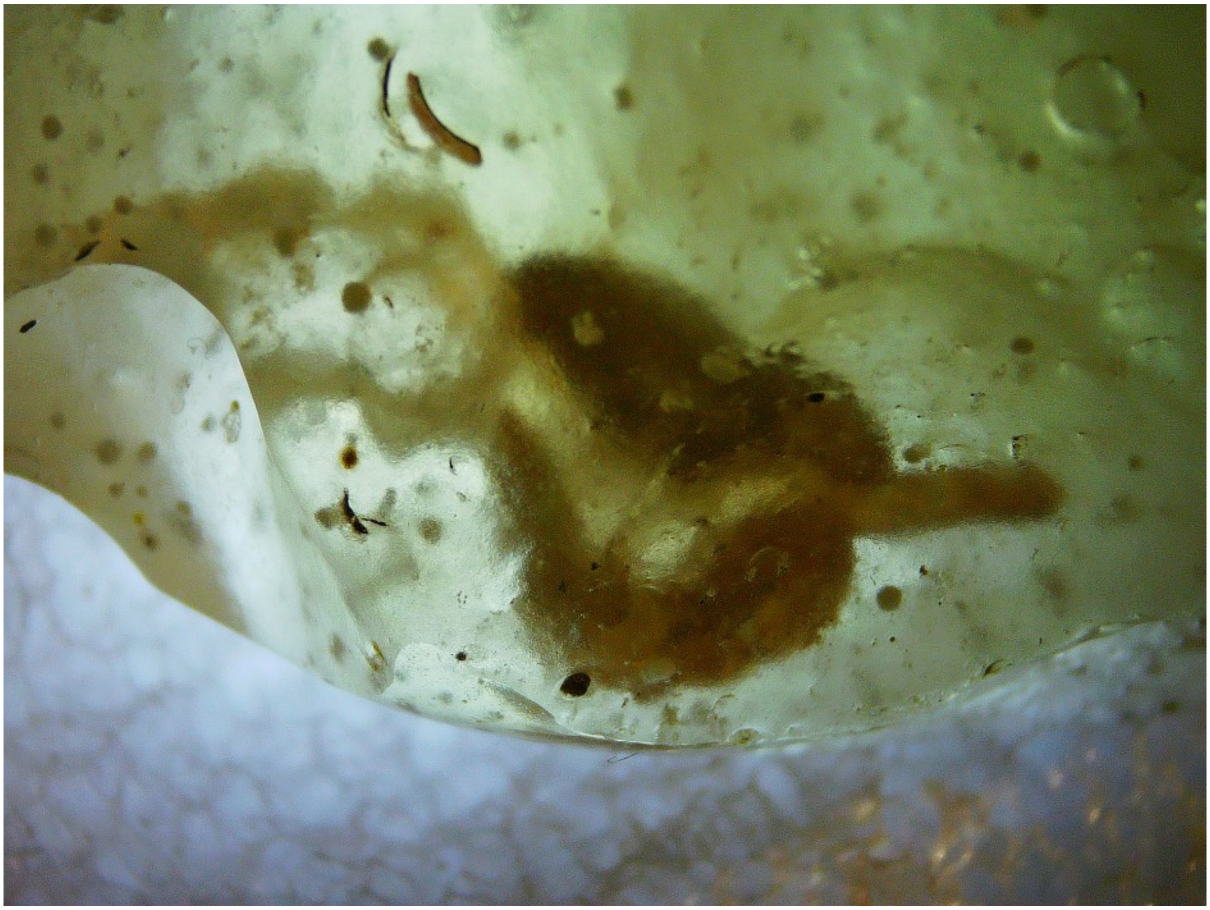
As shown in the image at the chapter start, the embedded object was close to the surface along the C side. I cut off the white opaque lump forming a point between the D and E sides and ground it down as above. The fossil image viewed through that flat is below. The inclusions and distortions don't help any. The stub sticking out to the right could be the stem which had supported the seeds, or it could be the stub of the stamen through which they were fertilized.



I ground and polished a contour at about a right angle to the big flat, as close to the object as felt safe. The fossil is viewed above through that flat. The old surface of the specimen forms an edge with the flat, starting at the bottom left and curving up to about the top center. The earlier view through the Karo looking into the opening would have been from a point left of this aspect. The lips of the pocket are at center right above, opening to the left. At the far left is the opening of the seed that had been buried with this pocket. The entire specimen is heavily loaded with cristobalite.

The relative heaviness of the lips suggests this was not an arbitrary splitting of a seed husk, but was the parting of a seam. But the remaining seed portion appears to be two or more times the length of this husk. So the husk probably grew around the seeds at first, and as the seeds ripened and grew they forced open the husk.

I took these images to a forum specializing in seed identification, but got no suggestions on what sort of plant it might have been.

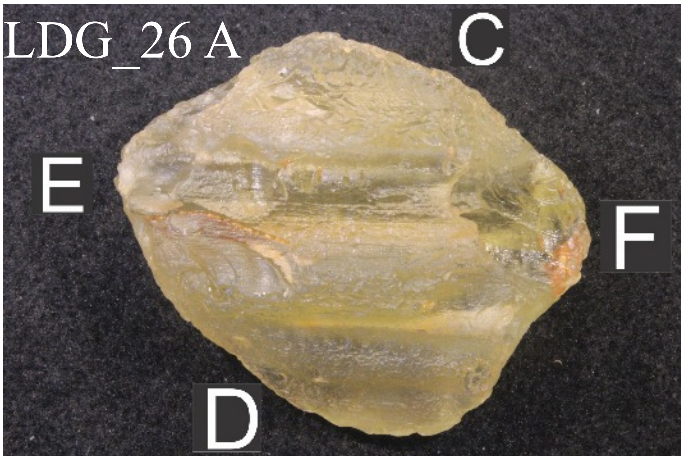


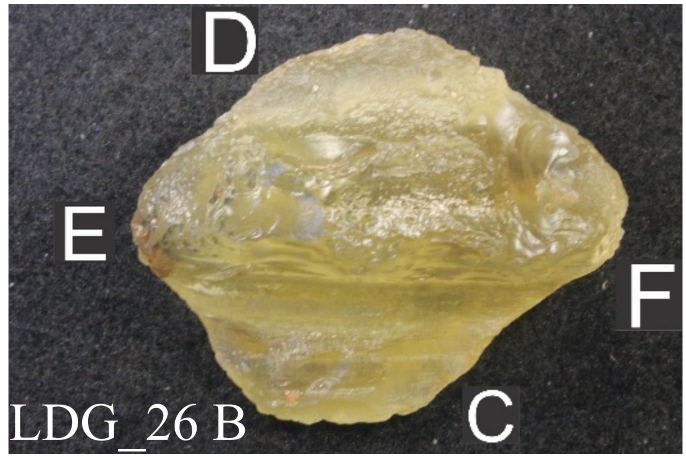
The silicone casts don't photograph well, at least for me. I used photogrammetry to create a 3D model of the cast, which is about 13 mm on its longest dimension, shown above. The most interesting aspect is that the seed apparently had an individual sheath, in addition to the larger cap-shaped figure shown still embedded in the glass. This is analogous to the hull of a Spanish peanut enclosing two nuts, where the nuts then have individual reddish husks.

There is a jagged seam running vertically through this image, just left of object center. On first viewing, it might seem that part of the inner sheath is missing over about half of the nut. But the half seed shown was entirely enclosed in the cap figure, so it's reasonable to say the entire inner sheath must have also been present. I suggest this shows that some portions of the sheath were flat against the seed, and parts had separated from the seed and were flat against the outer cap.

This interpretation is supported by the shift at the top of what we might label a neck, about object center. From there up, the left sheath is raised and the right sheath is depressed. From there down, the left sheath is depressed and the right is raised. So I suggest this is a crack in the sheath, and the left and right sides were skewed centered about mid-image, where the separation between them disappears entirely. When the liquefaction event happened, some fluid ran between the sheath and the nut, and some flowed more between the sheath and the cap.

I submit that this specimen is a fossil plant part. If there is some other explanation, it has eluded me. The delicacy of the preserved biology again argues against this glass ever having been molten.

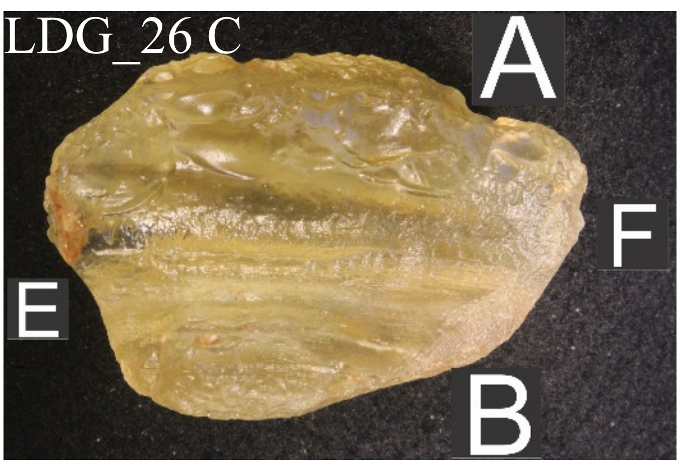


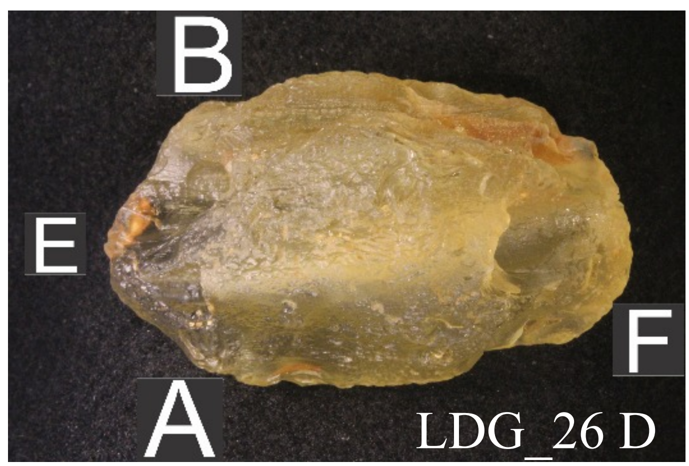


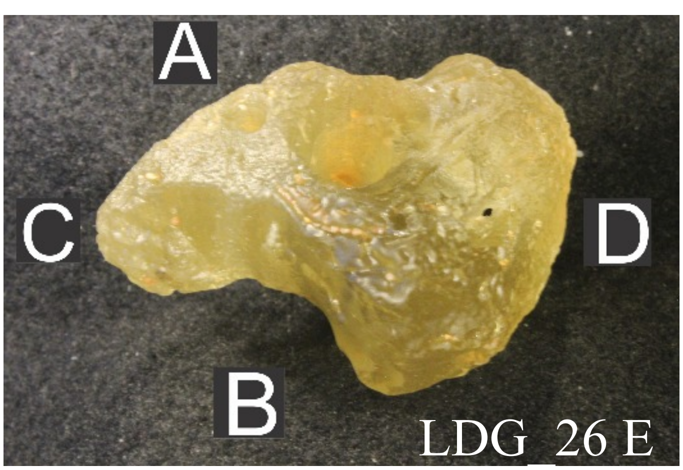
Sample 8 - LDG_26 - Sheaf of Plant Stalks

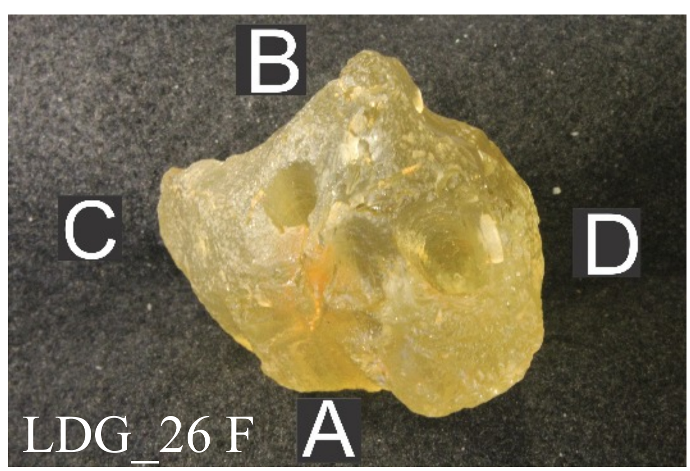
This piece features the most individual fossils in a single one of my specimens, with casts of nine plant stalks and two leaves. It illustrates how threads of grains can be laid down in a bed of plants, and possibly aligned by those plants.

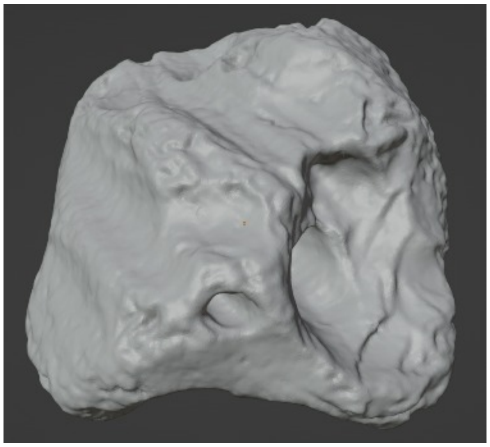
The specimen is about 2.5 inches long. Three of the stalk casts are completely contained in the piece, one going partway through. The remaining six are partial cylinder impressions around the outside. There are other minor dents that might be the tips of stalks.



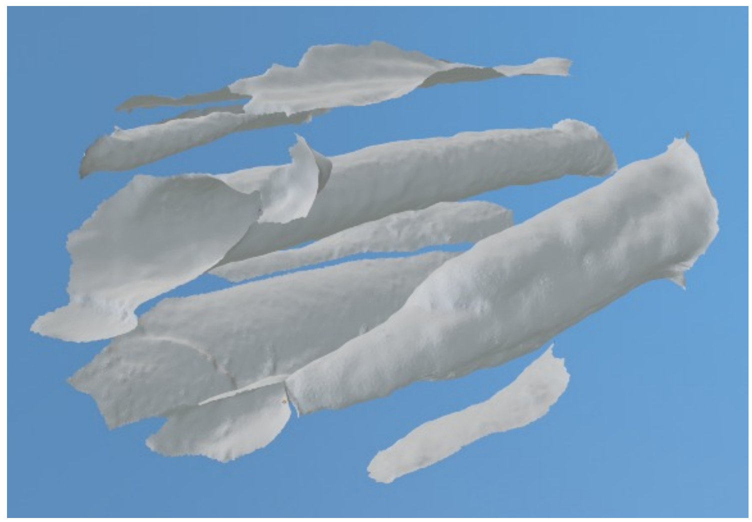






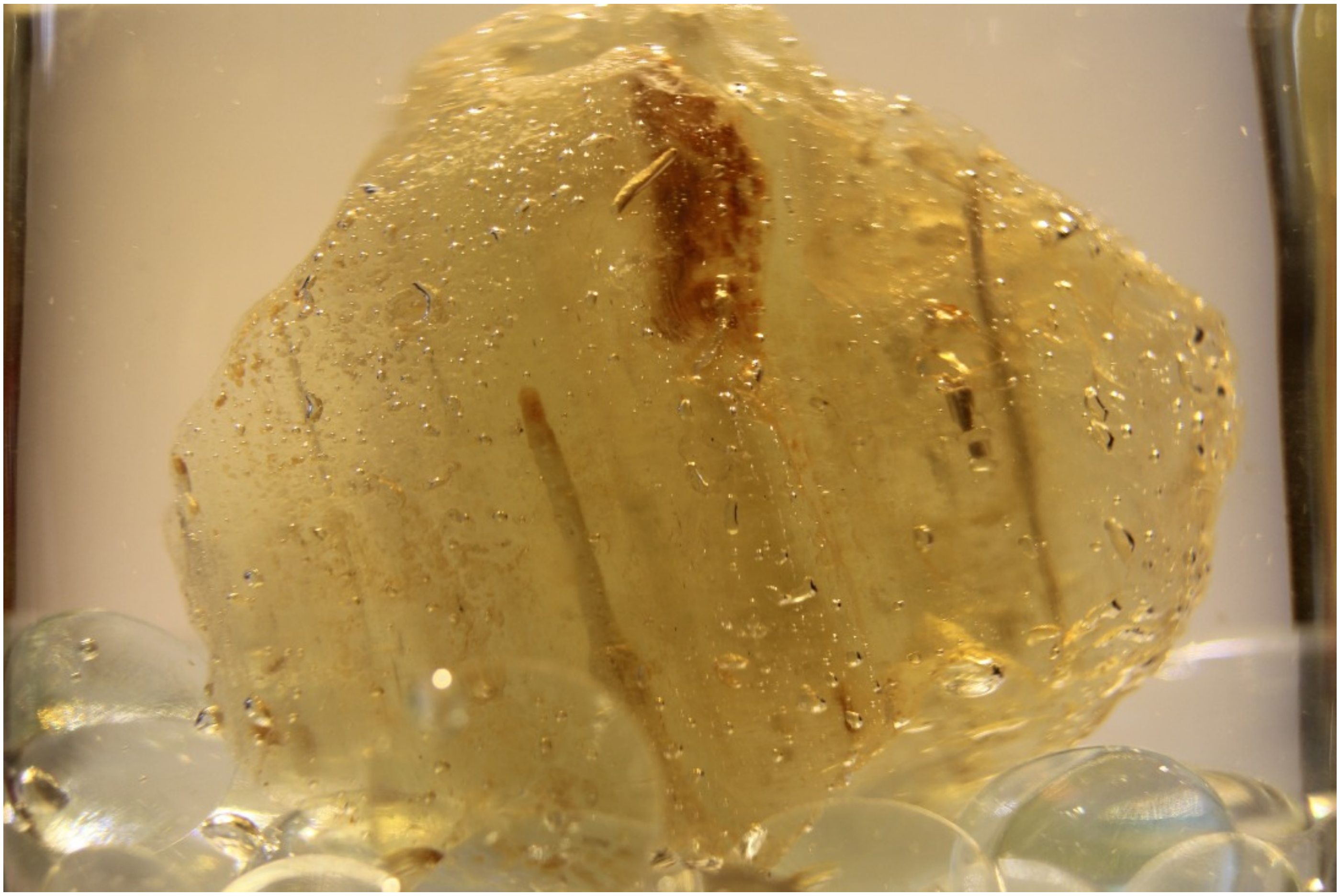


Photos of the exterior didn't give a good presentation of all the fossil imprints. As with other samples, I used photogrammetry to capture the exterior, made silicone casts of cavities, and captured them the same way in separate steps. I stitched those sub-models together, giving the model on the left.



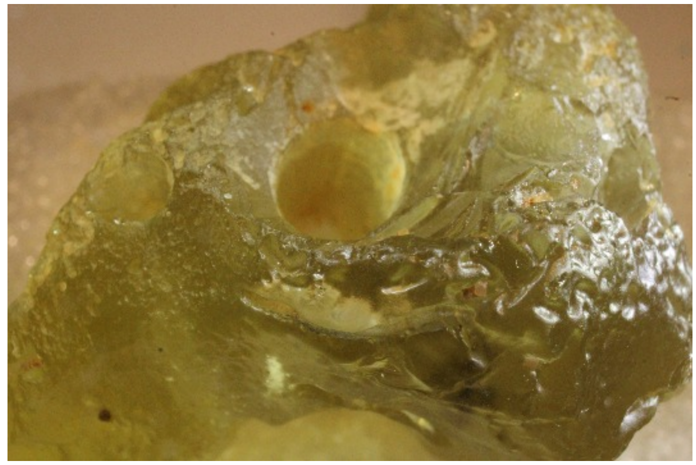
I pared away all of the exterior that was NOT a fossil imprint. I consider it to be an imprint if it is a cylindrical cast, partial cylindrical cast, or pronounced conical cast. The remaining images on this page are all those apparent fossils, viewed from different angles.

Two of the casts go all the way through the item, one of them tapering quite a bit and the other tapering only minimally. A third cast is smaller, tapering, and goes only partway through. The remaining casts are purely exterior. All these appear to be casts of stems or perhaps seeds at the ends of stems. There are also leaf casts which I don't show here. Note that these taper in opposing directions.



Viewing in a Super KaroVision bath shows internal bands of color changes. The largest leaf cast is at the top, and connects along one side to the largest through-cavity for nearly half that cavity's length. It is filled with fine sand and silt, which gives it color. The small tapering cavity that goes only partway through is at the bottom center angling up from the bottom.

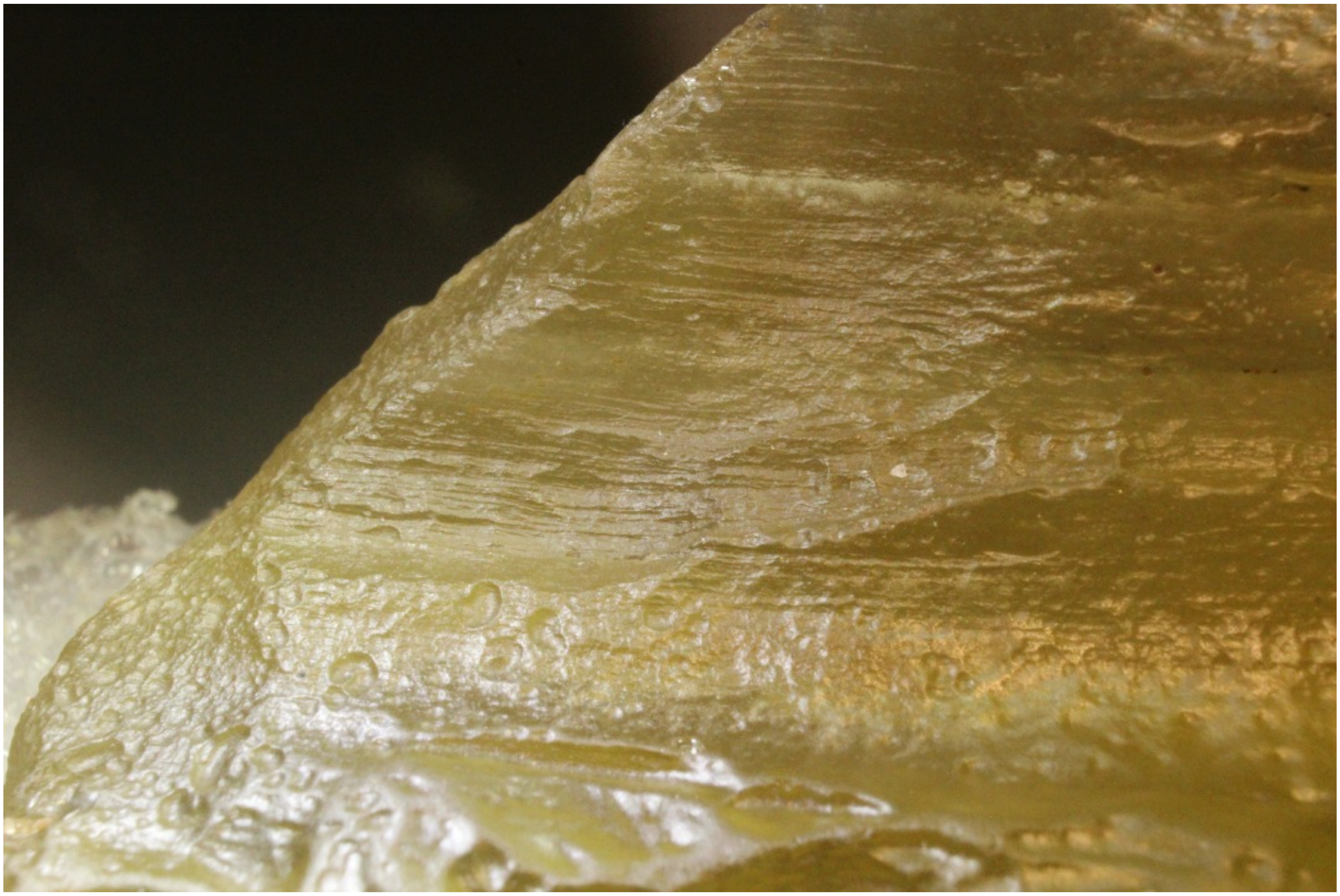
Some of the color bands appear to be on the exterior, but some are clearly internal to the glass. Presumably this marked horizontal when the sand was laid down, so this specimen records a sheaf of plant stems lying flat on the ground. The fossils include both tips and other segments, so this might represent either stems of different maturities, or a random collection from different plants fallen together. Because the casts don't taper in a consistent direction, they likely didn't fall at one time. This collection might mark some furrow or rock where stems collected over time from varying breezes.



The largest leaf cast is above left, after removing the sand. This joins with one of the through-holes. The extreme end of it at the right side doesn't show any taper as a crack would, but ends in the same width as the rest of it shows. The next largest leaf cast is above right, and partly circles one of the through-holes. This is the same pattern as other specimens here have shown, and presumably this was a leaf growing on this stem.

The leaf tip is the most common fossil type I've found. The deeper a leaf cast, the more fragile it is. As the surface wears by tumbling down wadis, deep cast walls will break off readily. The shorter the remaining cast, the less preferential wear, so the longer the cast will survive. Shallow casts probably wear little more than a plain surface.

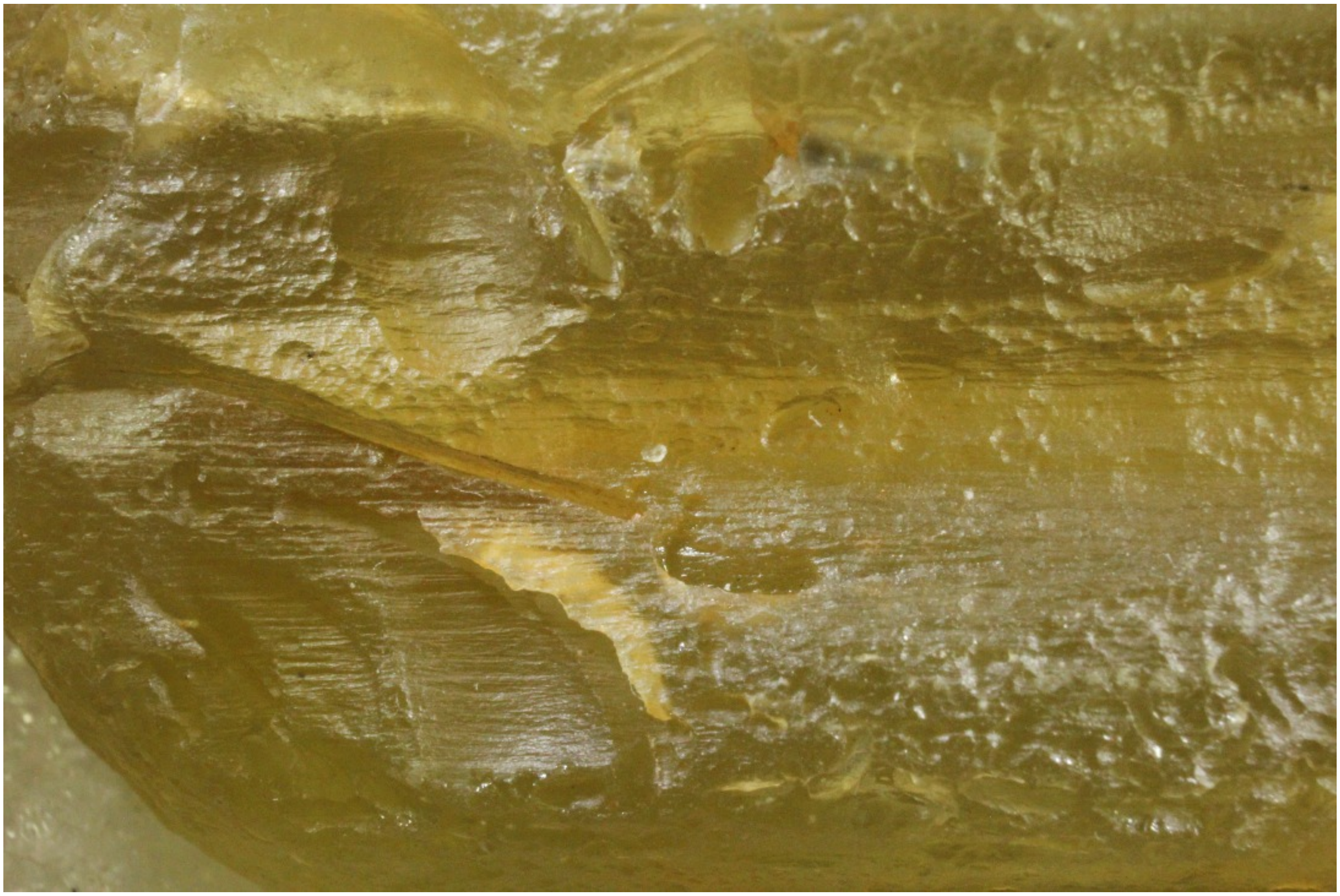
All the through-holes show some kind of white accretion aligned more or less on the same horizon. This appears to be overlaid on the original surface and later breaks and erosion. I take it to be something laid on when the specimen was lying in water, and might be an evaporation product.



About half of the surface is covered with striations. These are inside the cylindrical prints of stems, and also on the higher curves between those prints. They are all aligned the same, and follow the same organization in other samples. That is, they don't branch, they don't curve around obstacles or corners, they don't conflict on a surface.

The image above is a sample of these striations on the B side. The contours on the right side are part of the corrugation of stems and higher edges, with striations along the bottoms and on the upper curves. A large fragment has broken off on the upper left, with the fracture rising in a curve to meet the right side surface. The steeper portion of that slope shows no organized striations. The flatter part of the fracture on the left side again shows the striations aligned with the others.

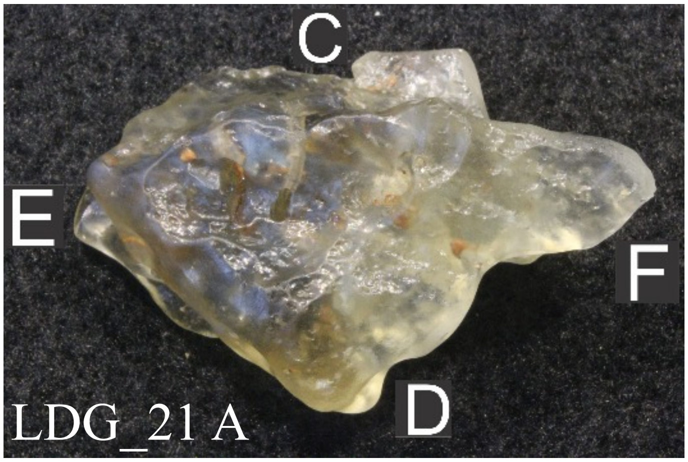
Striations are not like rings on a tree. A considerable mass of sand threads can be laid down in a single event, perhaps in a few minutes. So the alignment might not reflect consistent winds. The stems here, by being parallel yet in opposing directions, suggest there is something causing fallen plants to line up, blown perhaps against some obstacle. This might explain why the chained crystals are aligned with the fallen stems, blown by similar but later breezes, and the stems themselves might help the threads grow among them.

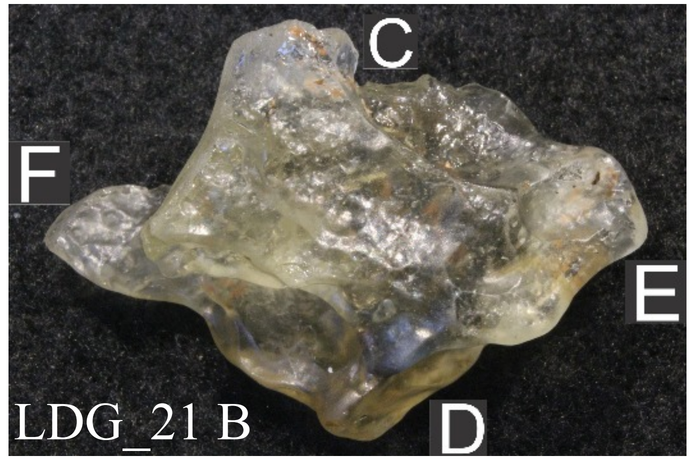


The above image is on the A side at the D end, showing the largest leaf cast. Where the surface is generally flat and not too pitted, the striations are regular and follow the alignment shown elsewhere on the sample. There are a couple of fractures at the lower left, and in each case the striations appear on the newly fractured surface aligned with the rest. This is not something organic applying detail to the surface, but something in the structure of the piece, brought out by etching where a fresh surface is exposed.

The striations progress right up to the leaf that cuts across them, indicating that the sand grains are able to chain tightly against an obstacle. This would agree with my model describing sand grains falling slowly under the influence of a static charge, and fitting into the best packing on the surface. Toward the upper part of the leaf cast, just before it curves downward toward the left, an area of pits becomes mixed with striations, but does not replace them completely.

The two largest leaf casts appear to grow off of stems like they might in grasses. The largest one is attached to a stem for a distance of about two cm, but there is no way to gauge what portion of the leaf is preserved here. The second partially rings its stem and is preserved here as a curled tip. Finally, in the images of the various casts in relation to each other, one of the tapered casts appears to be a leaf starting to separate at the growing tip of the plant. The stems are all round in cross section, and if they are grasses then the roundness is evidence that no great shock was involved in the formative event.

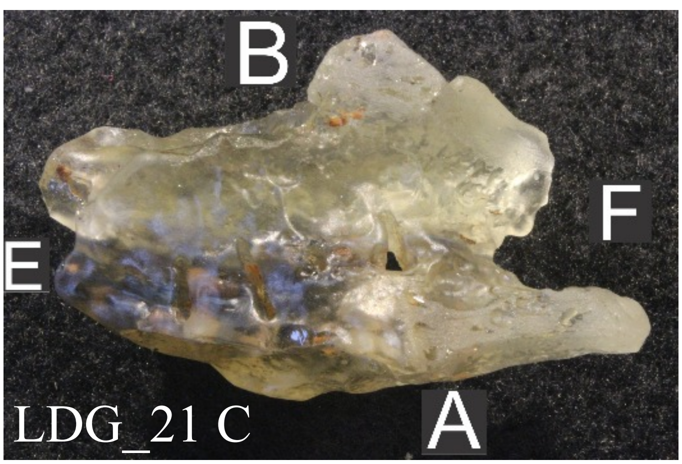


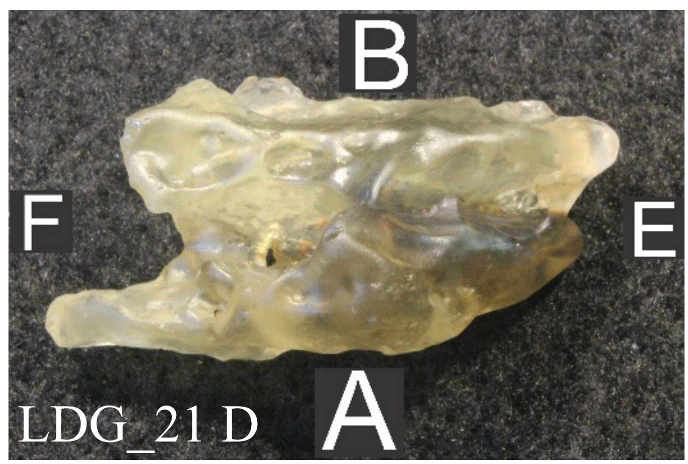


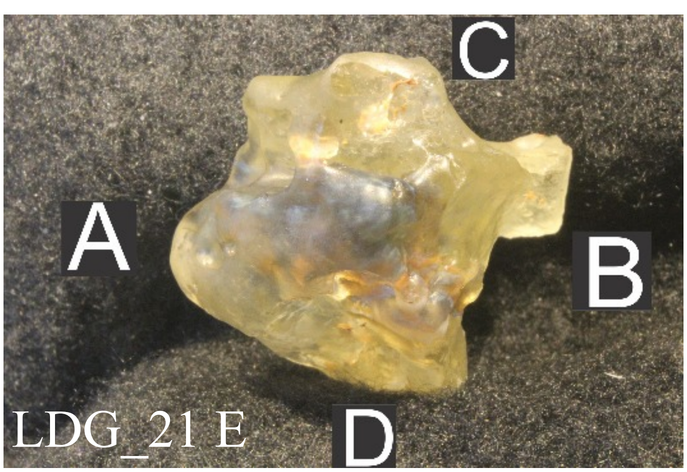
Sample 9 - LDG_21 - Insect Nest Connections

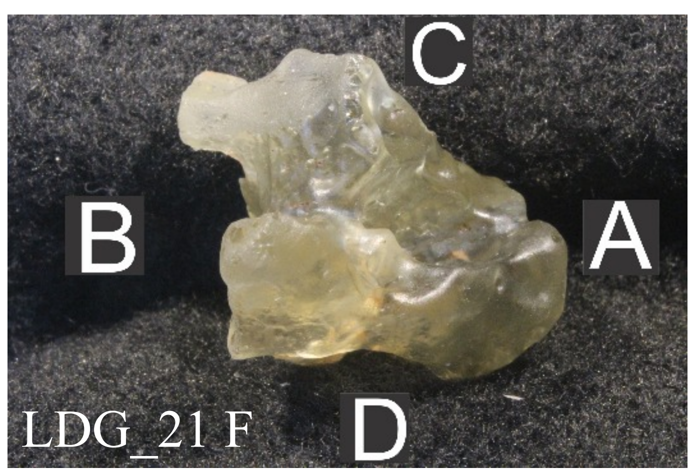
This sample has no obvious striations or crystal bundles. Its value is in adding to the evidence that impact shock is not a plausible formative event for LDG.

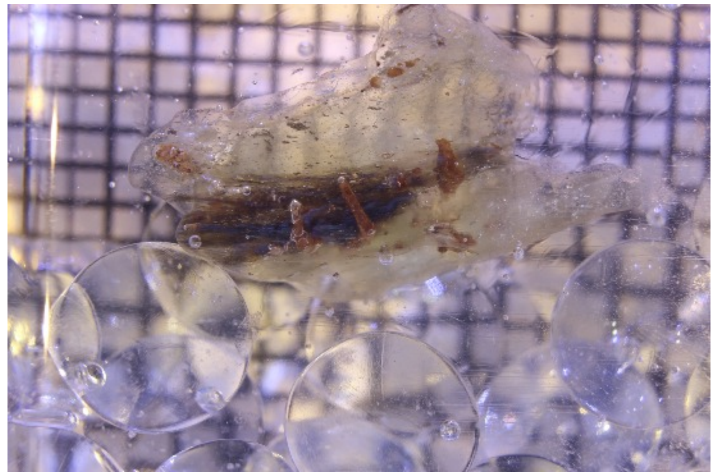
This specimen is about 1.5” on its longest dimension, and seems to be a node of relatively solid material forming a junction between several chambers of an insect nest.





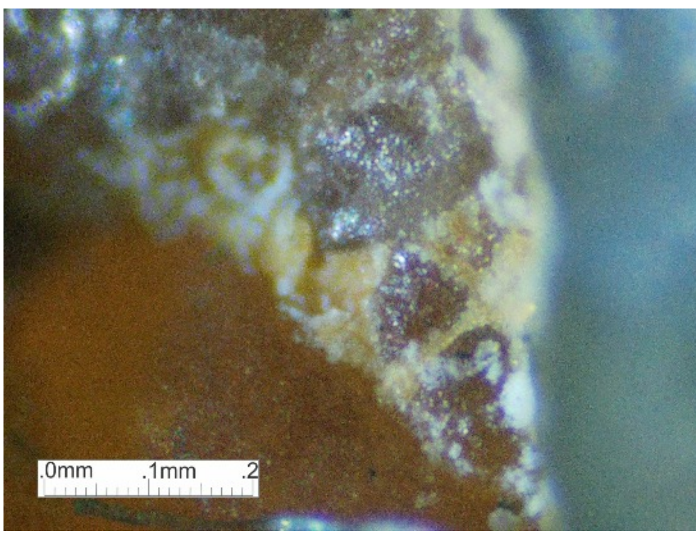


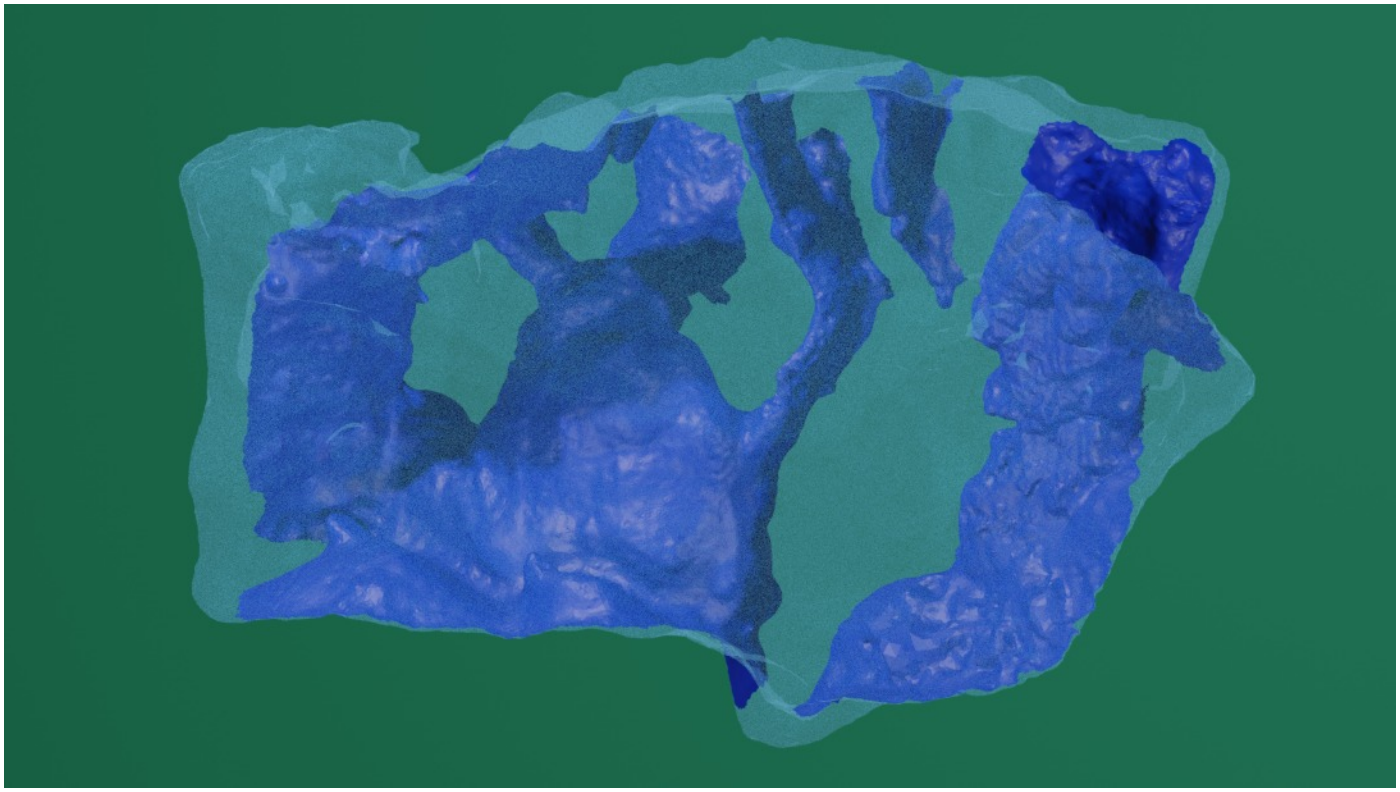




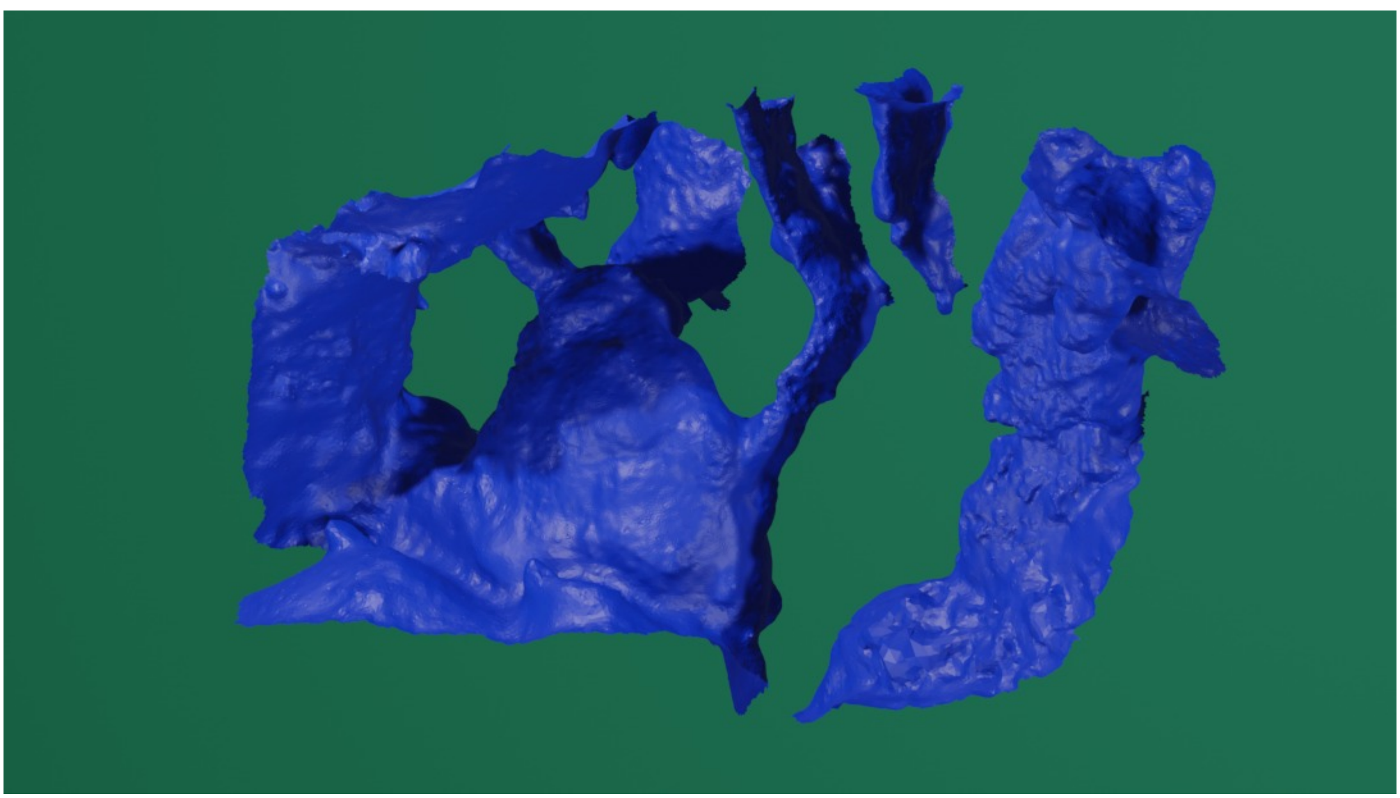
My first impression was of an insect fossil. The image above left shows what appear to be legs, perhaps in the act of grasping an object. Viewed through Karo Syrup above right, this impression is even clearer.

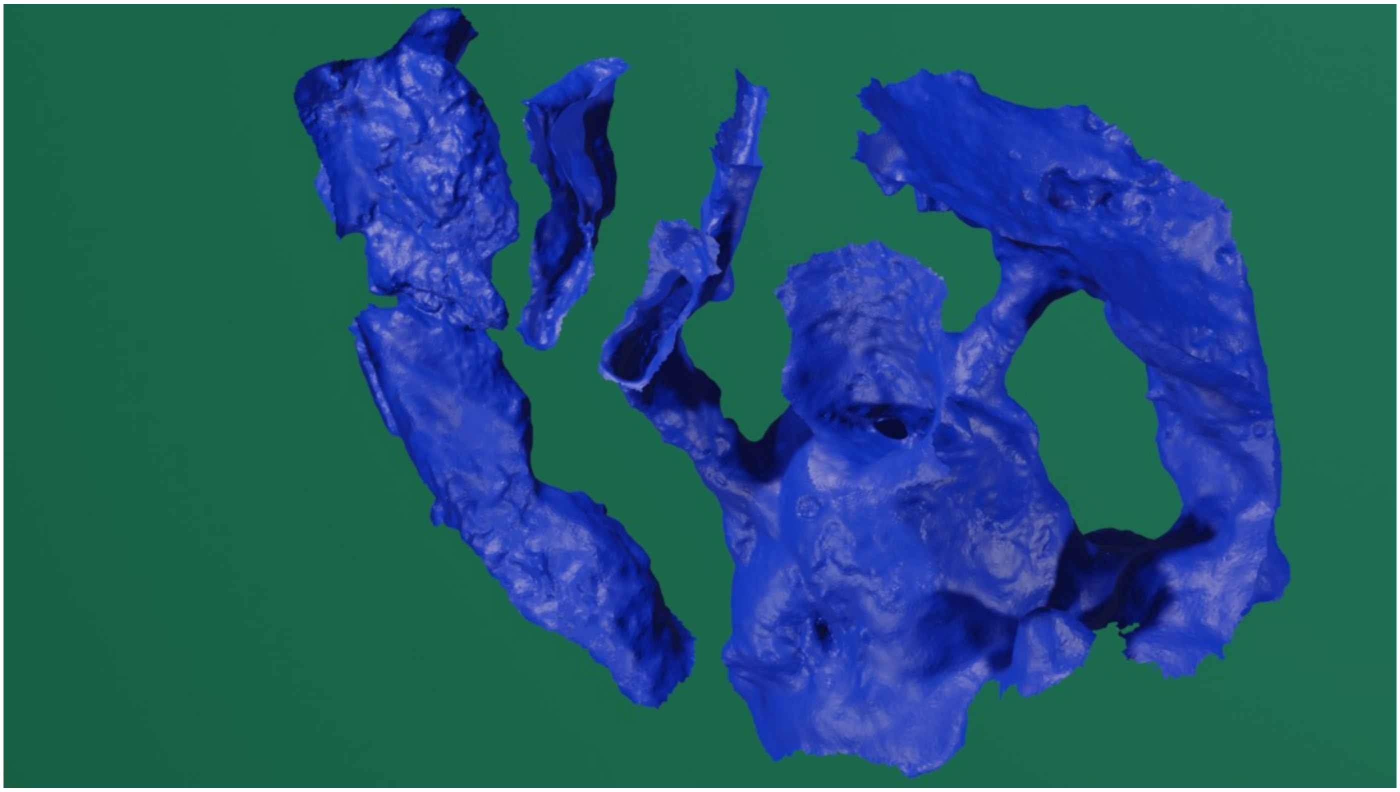
On closer inspection, the voids were filled with sand grains wedged into the tapered spaces in decreasing sizes, all cemented with perhaps pollen. After picks and solvents cleared the sand, what appeared were tunnels.



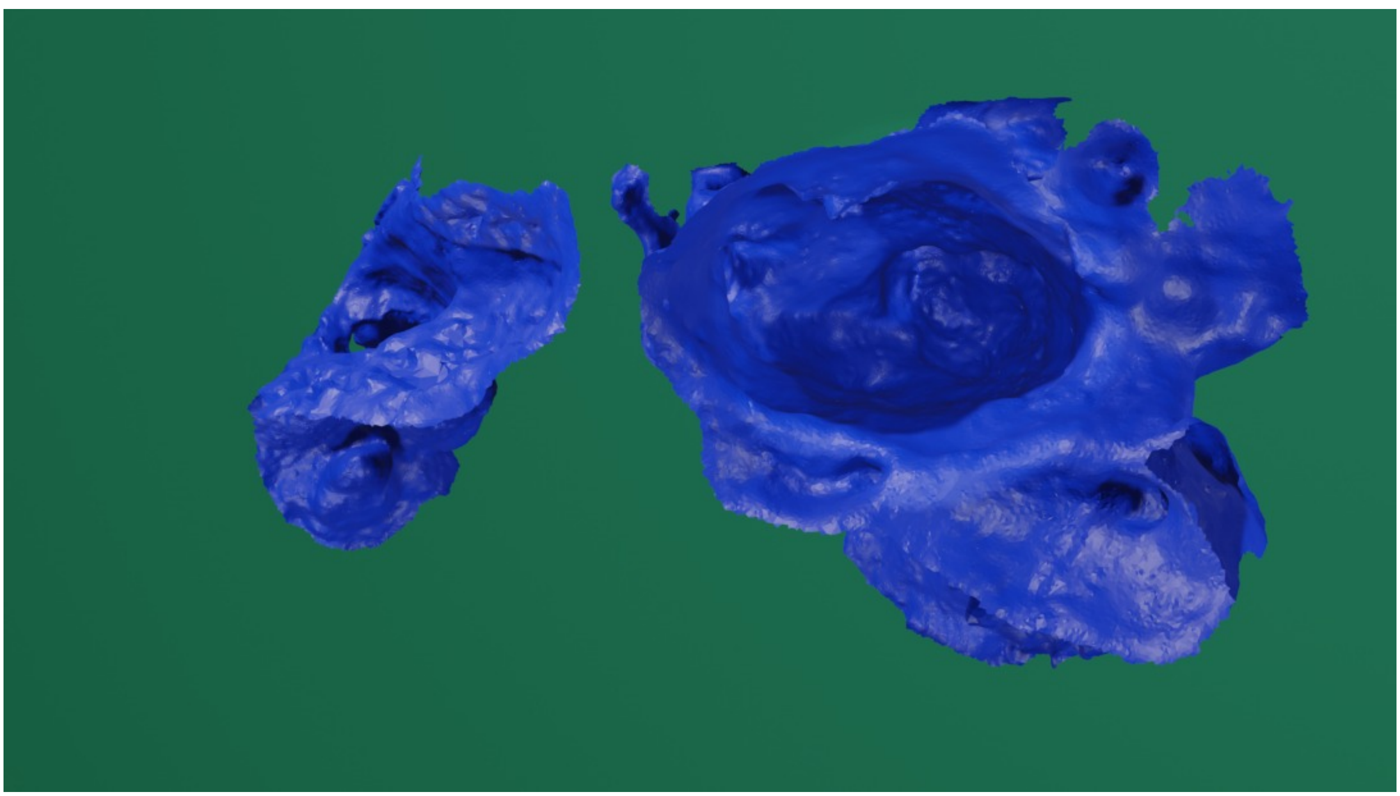


As with other samples, I used photogrammetry to capture the outer contours, and cast silicone to capture the cavities. The cavities are shown above in their relation to the outside contour, and below in isolation, both from the B side. They appear to consist of the end of one major chamber coming up from below as seen here, and slices of two chambers on the left and right, all connected by tunnels. None of these are dead-ends or isolated cavities, but all connect to the outside, i.e. other chambers. If there were any isolates, it would argue that these are natural bubbles created during the formative event.





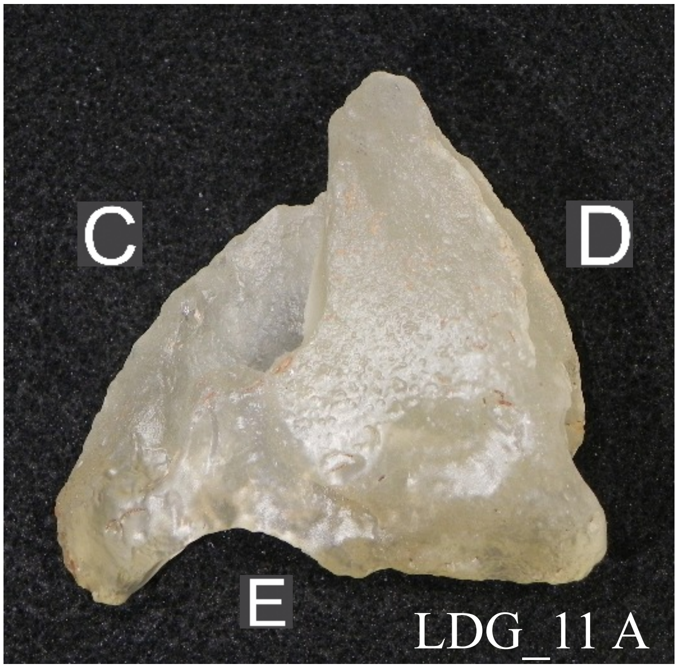
Seen here from the A side, a short tunnel on the left connects two concave features on the exterior. The small fragment is a slice of tunnel opening to two concave features on the C (top) and A sides. The largest pocket on the D (bottom) connects to multiple voids, including twice to the feature bridging the C and F faces. Below, the view from the D-F aspect shows the interior of the largest void.

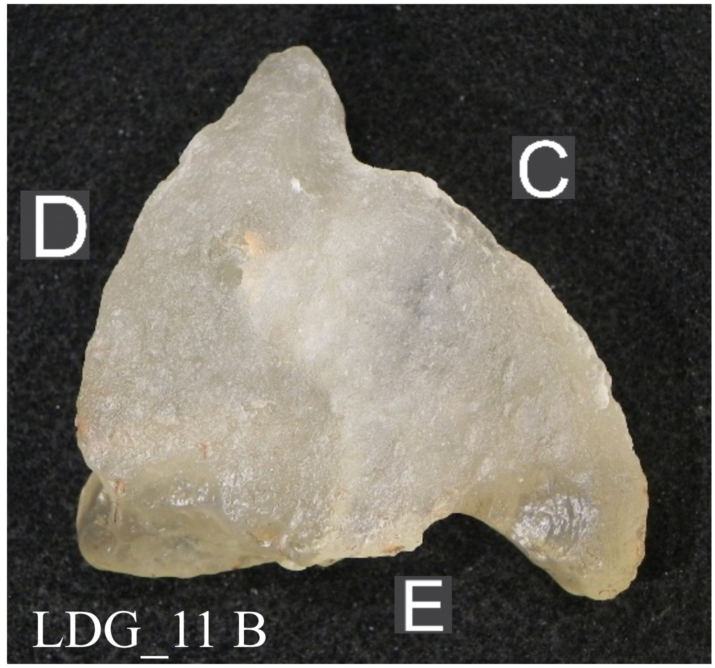


Above left is a portion of an ant nest on eBay. If this were captured by the LDG formative event and broken up over time, we would expect it to fracture where chambers and closely-packed tunnels create weak spots. This leaves the junctions such as the one in the (grainy) close-up to the right, where a higher ratio of glass makes it more robust. That appears to be why we have this item.

This specimen has tunnels which seem consistently flattened, but the flattening follows multiple axes as the tunnels turn. Their cross section is probably a characteristic of the ant species rather than indicating compression or settling.

This item says nothing about my thread crystals. This sand may have been laid down in threads before the ants used it, but there's not enough material to evaluate. The structure's overall delicacy does, however, add to the evidence that there was no substantial shock in the formative event.

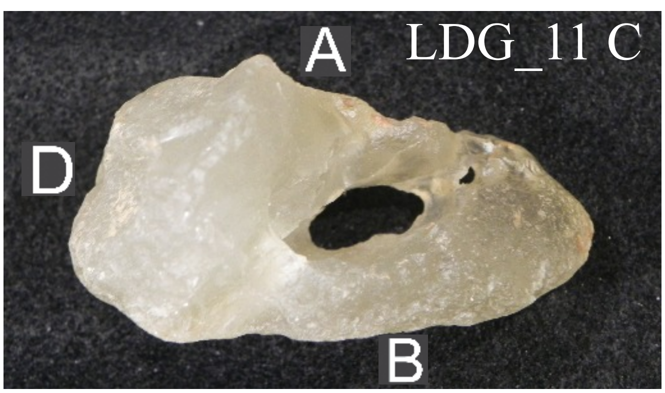


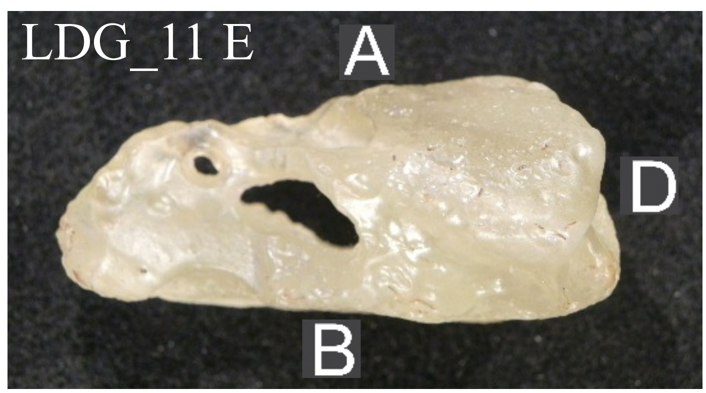


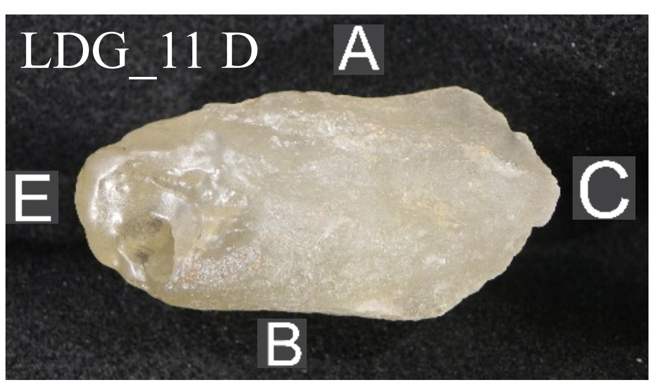
Sample 10 - LDG_11 - Insect Nest

This item shows the consistent alignment of threaded crystals, but its most striking contribution is the evidence against any significant shock or heat in the formative event. This fragile specimen had no business surviving 30 million years in the wild.

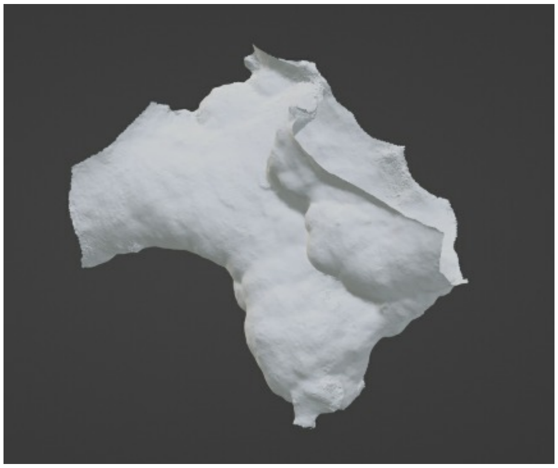
The piece is just under three inches on a side, and about 1.25 inches at its thickest. It has a large central cavity resembling a ground nest of ants or wasps, having three external holes and a complex interior. The central cavity preserves some very detailed surfaces that were clearly protected from impact.





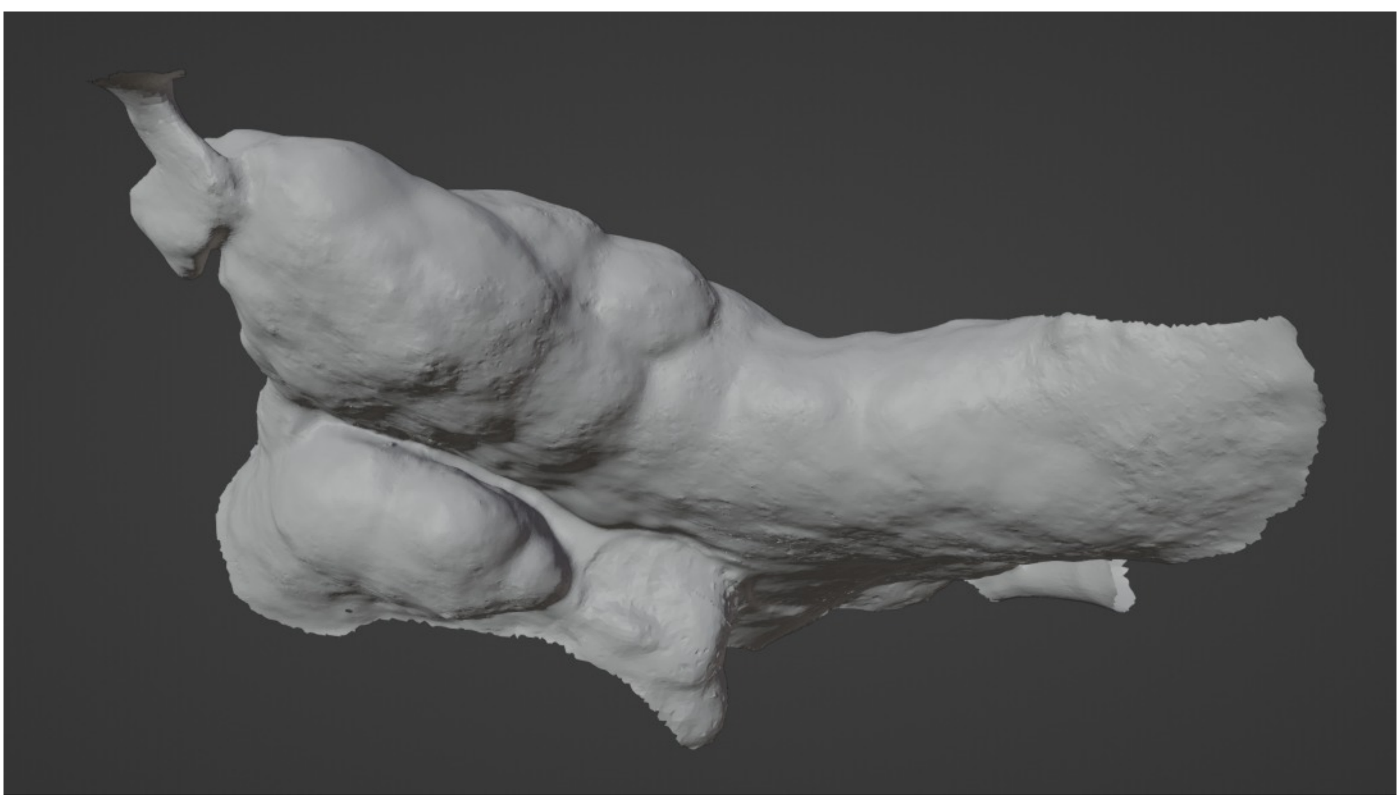


The main cavity is complicated, so I made a 3D model to better understand the configuration. As with the LDG_05 specimen, I used photogrammetry to model the exterior. I cast a silicon mold of the cavity, scanned it the same way, and married the two pieces. The following images were generated from the 3D model of the silicon mold.

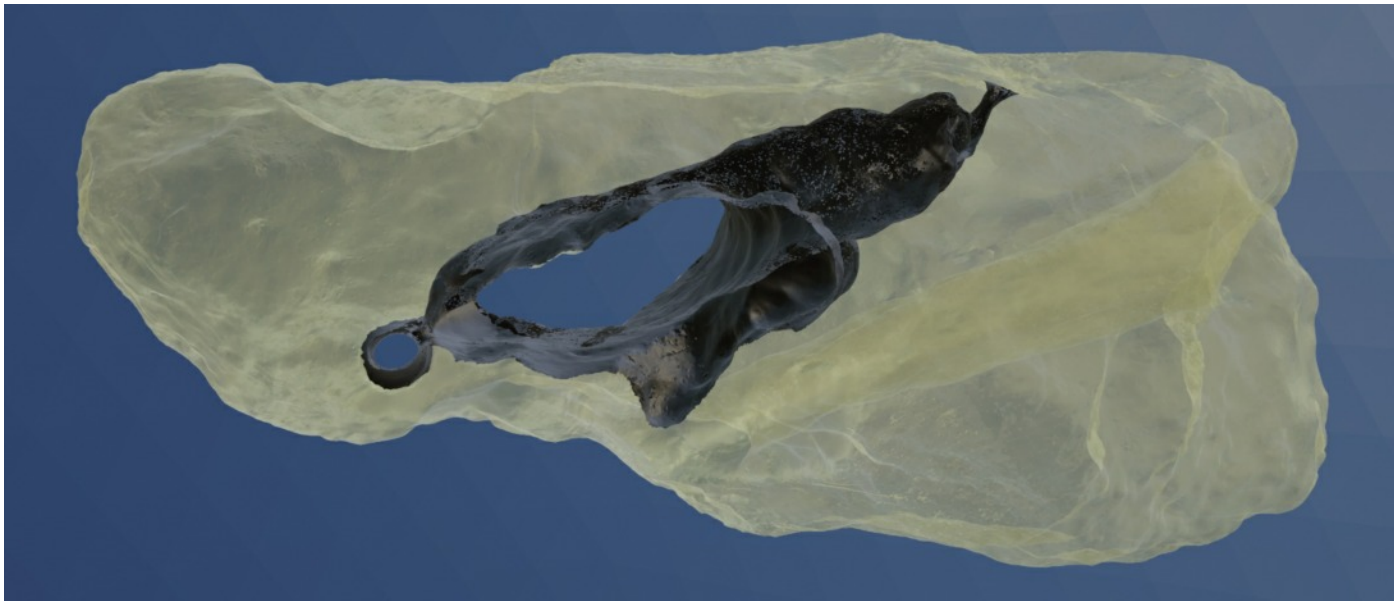


This is a prima facie ground nest for some insect. I publicized the cavity alone to solicit opinions, which were interesting. Some viewed this as a bubble formed in molten glass.

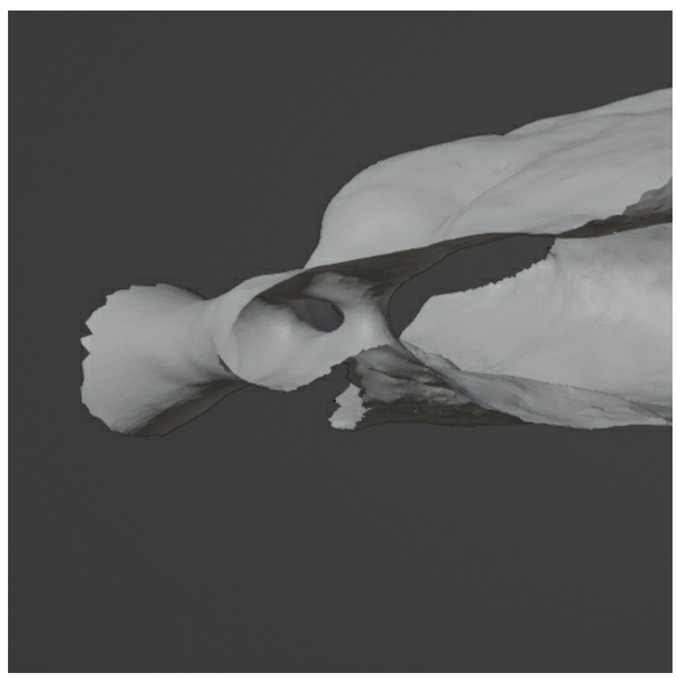
The image below is the nest after being stitched to the exterior, then re-pruned to merge parts of the nest that had been captured in the exterior scan. It is shown here in what may have been roughly the original orientation. The small tunnel at top left opens to the outside of the specimen, and seems to be one of the surface entrances to the nest. The small vestibule off the tunnel may have been part of the nest security design.



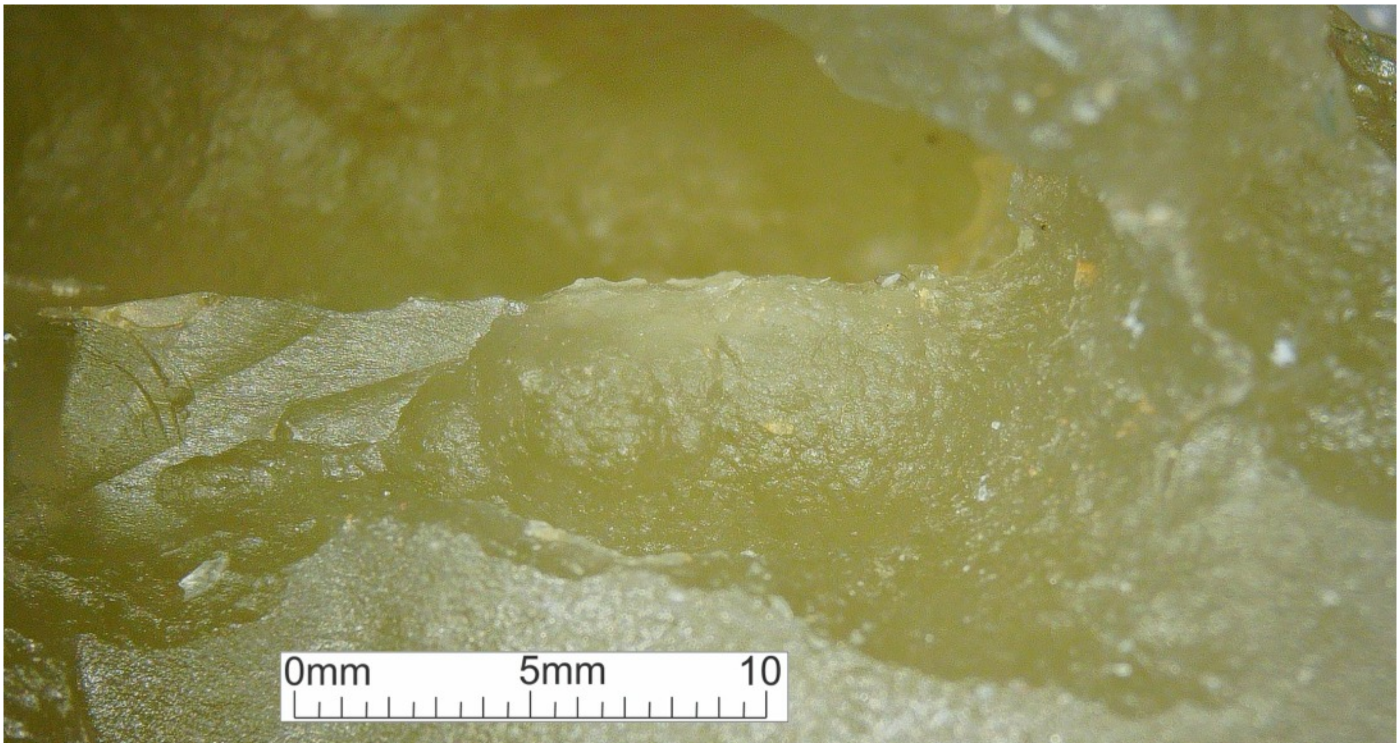
These images show the nest portion in black, in its proper position in the whole specimen. The first image below is posed with the apparent entrance tunnel on top. What is here shown as the underside had fingertip-size dents that I initially took to be seed casts. The nest portion shown clearly connects to more space on either side of the large openings shown. The most plausible explanation for the exterior dents is that they are the remains of a nest complex.

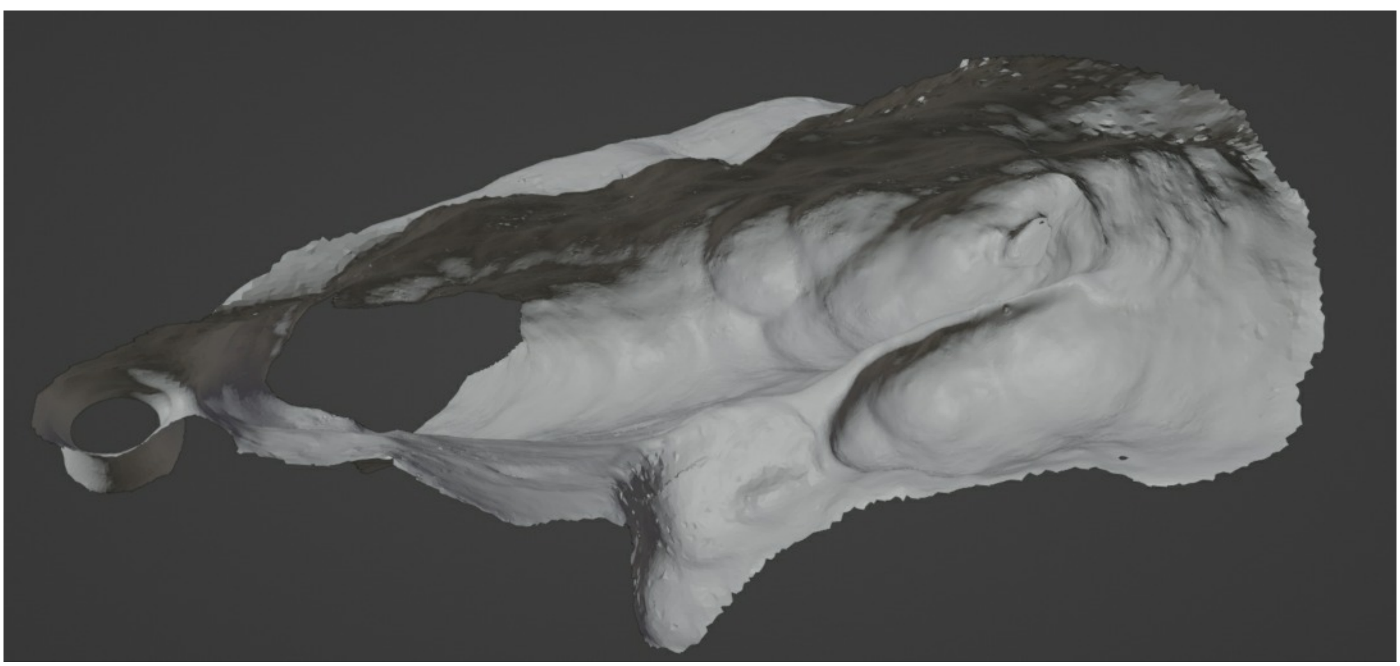


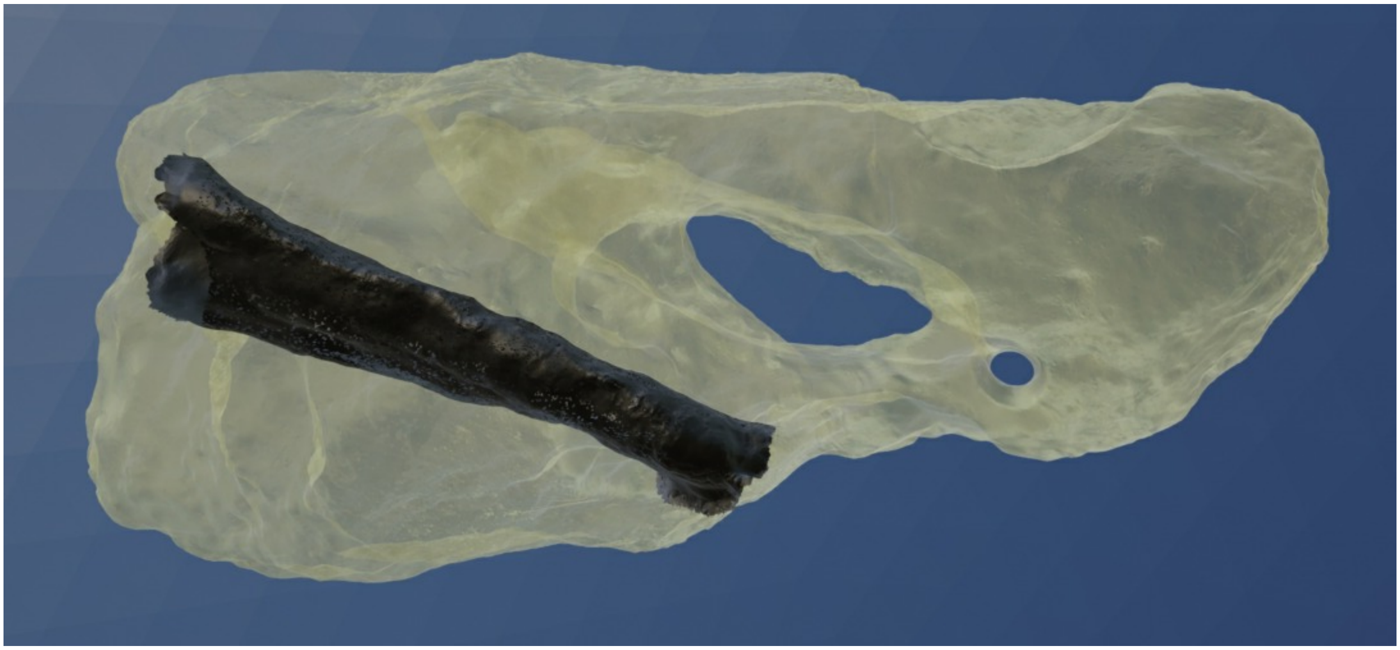
The image below left shows the black nest cavity in a bottom view. The image below right shows an apparent tunnel for the nest.



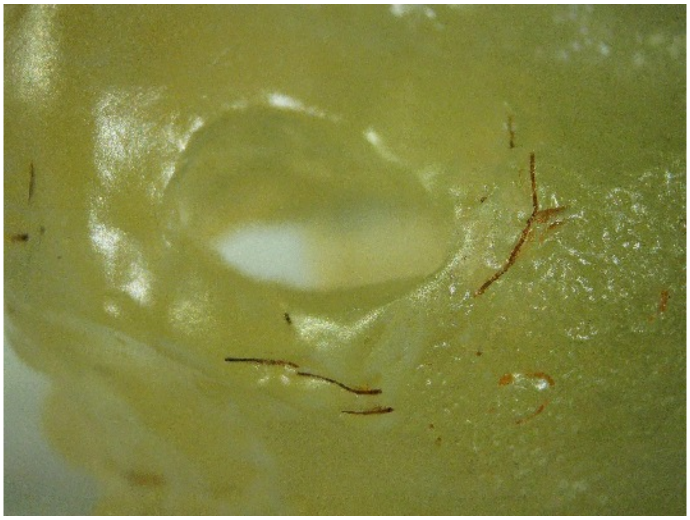
The major cavity appears to have consisted of at least three compartments. The partitions were fractured when a large part broke off, leaving a thin membrane between two of them, and a triangular island where three of them met. The largest piece of membrane (center in the image below) is quite sharp, probably due to the fracture. Note the glossy triangular area on the left with fine striations. Those line up with striations I will point out later, indicating that the sand was laid down agreeing with my thread model, before the insects dug their nest. The striations being straight and aligned means these cavities are not bubbles that were blown during the formative event. These are threads distinguished by etching after being exposed by a fracture.



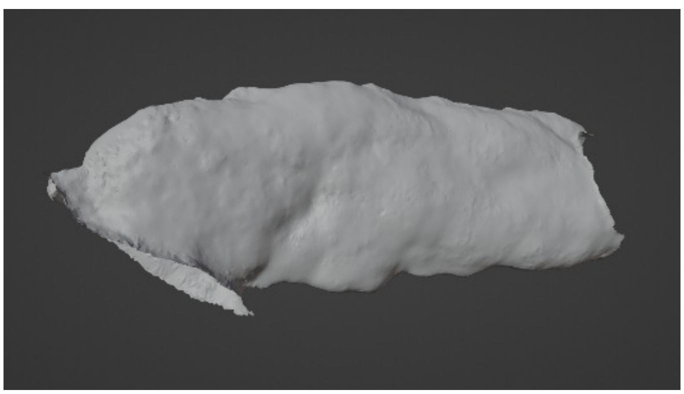
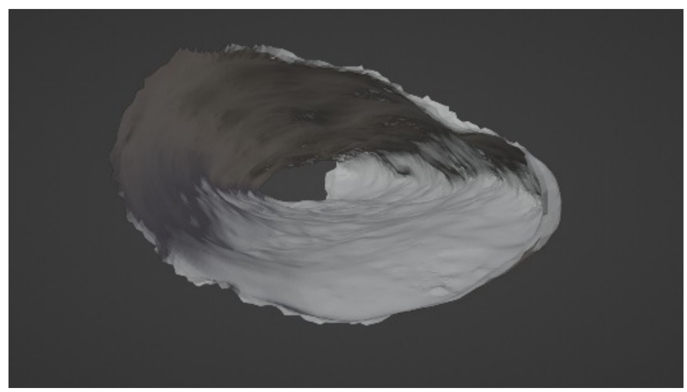




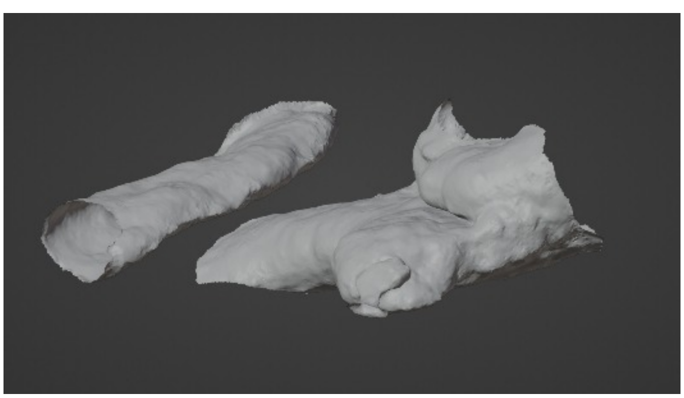
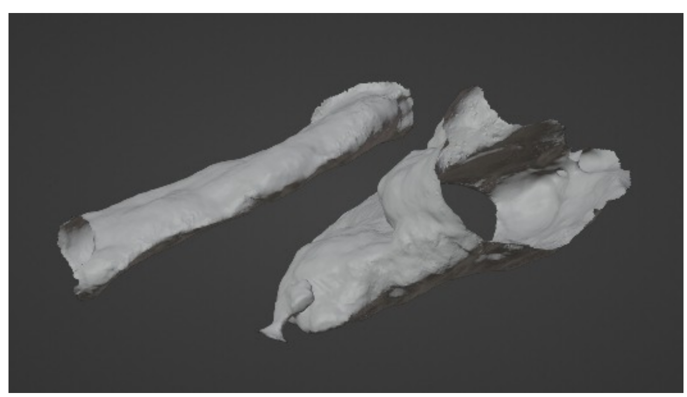
The second major cavity in this specimen is long and straight, suspiciously straight for an insect tunnel. Initially I tentatively identified it as a seed or stem cast.




Identifying it as a seed or stem cast primarily came from what appeared to be a smooth and regular shape, along with apparent leaf fragments near the presumed upper end of the cavity, as in the above images. But the images below show how closely the cavity's surface resembles the surface in the nest. So this might be another part of the nest, or a cast of some plant.

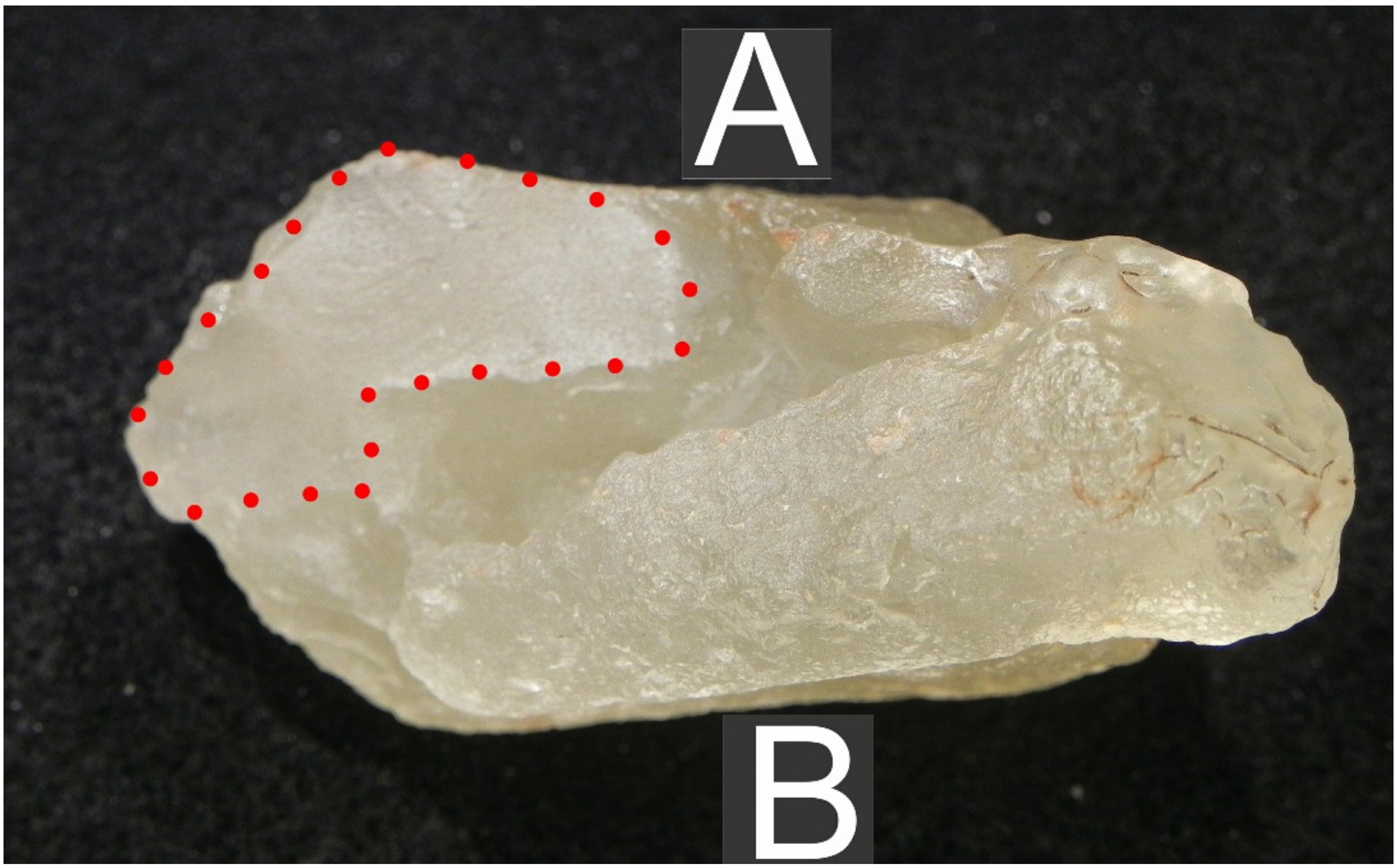



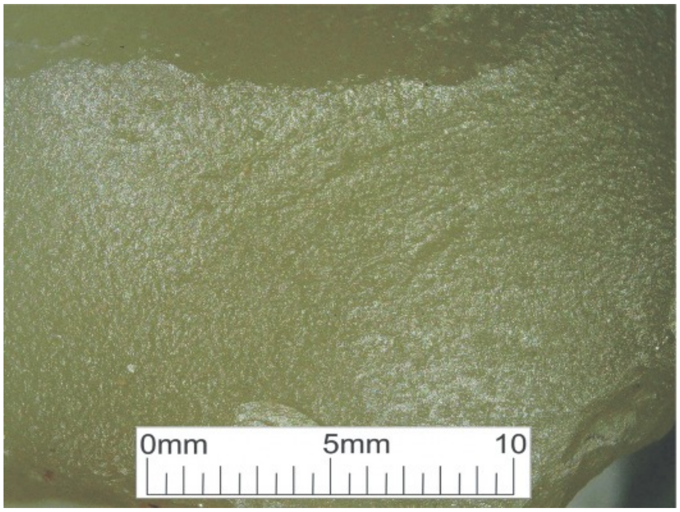
The following images show the two main cavities in correct relation.

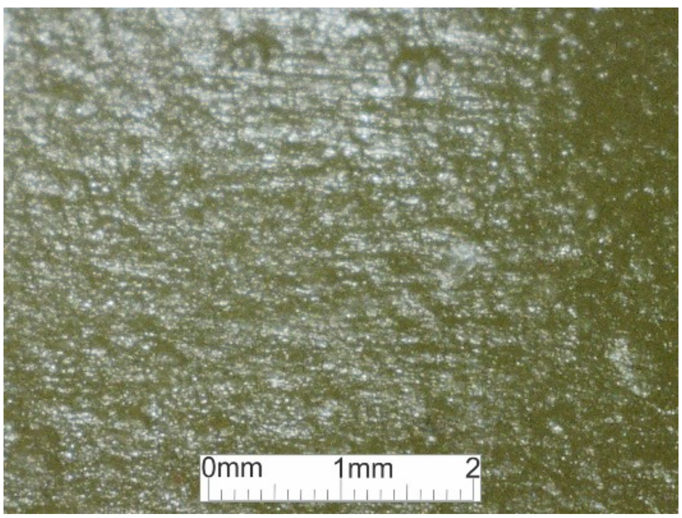



A large flat face is visible flat-on from the C side, and makes a vertical line in the A image at the chapter start, running from the top point and down about half way. This is a fracture which has been later etched. The image below shows the face from the C side, outlined in red dots. The inner angle of the red dots encloses one corner of the main cavity, and the breaking of this plane probably included breaking up the thin membrane inside the main cavity. The entire specimen tapers toward the E side (right), and the C-E point is on the image right end. Note the scattered apparent leaf tips on the right end.

The striations across the large flat face (next page) show that this face is closely aligned to crystal threads. This suggests that the strength of those crystals guides fractures to follow such planes.

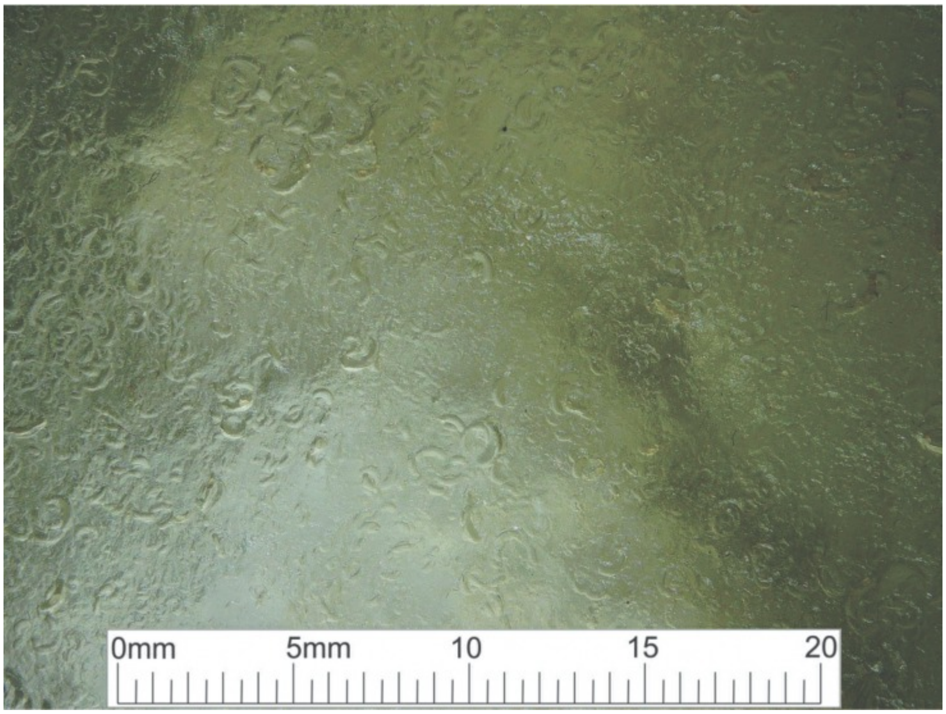




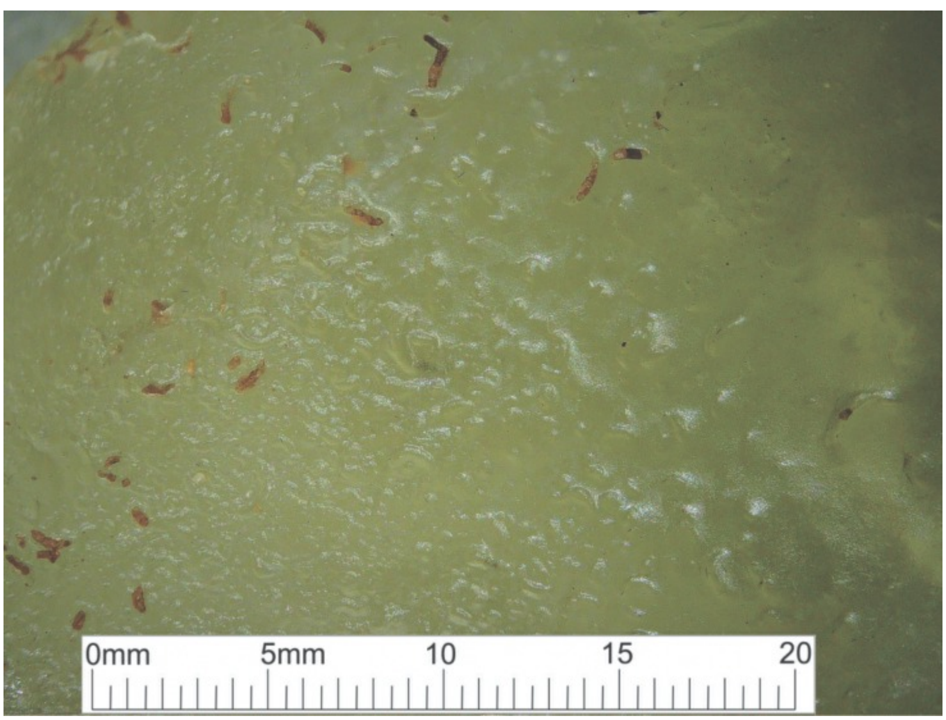


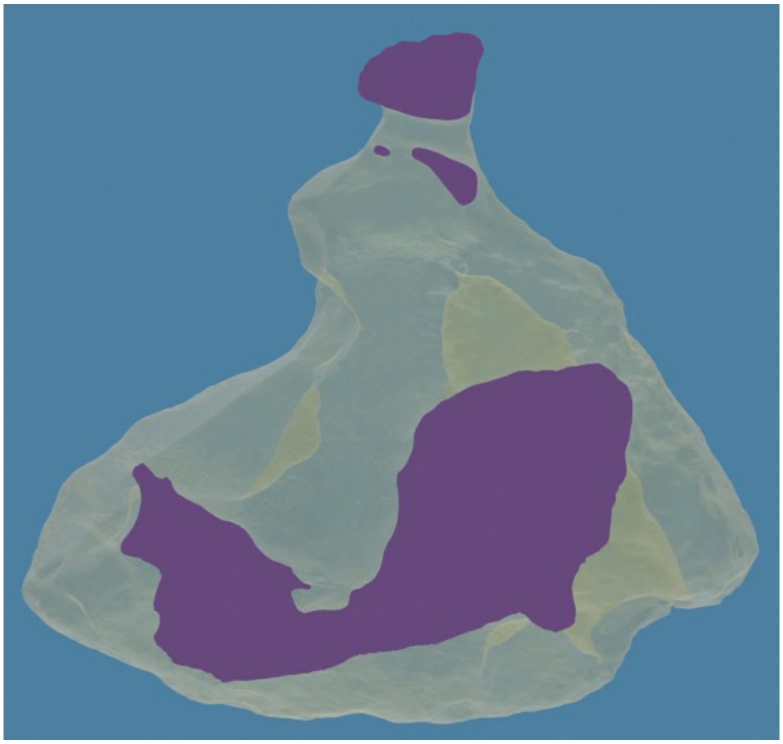
The image top left shows the conchoidal ripples somewhat obscured by striations. The top right shows horizontal striations at the peak of the flat face where it meets the A side. Bottom left shows striations farther down on the flat face.

The D side is the reverse side of the flat face, and has some pits on it. At the bottom of a pit opposite the flat face are striations shown at bottom right. These are parallel with the flat face. The triangular fracture remnants mentioned earlier inside the main cavity are similarly parallel to this face and show the same etched striations. Within the sense of my thesis, these faces give enough alignment information to say the piece was horizontal along these lines.



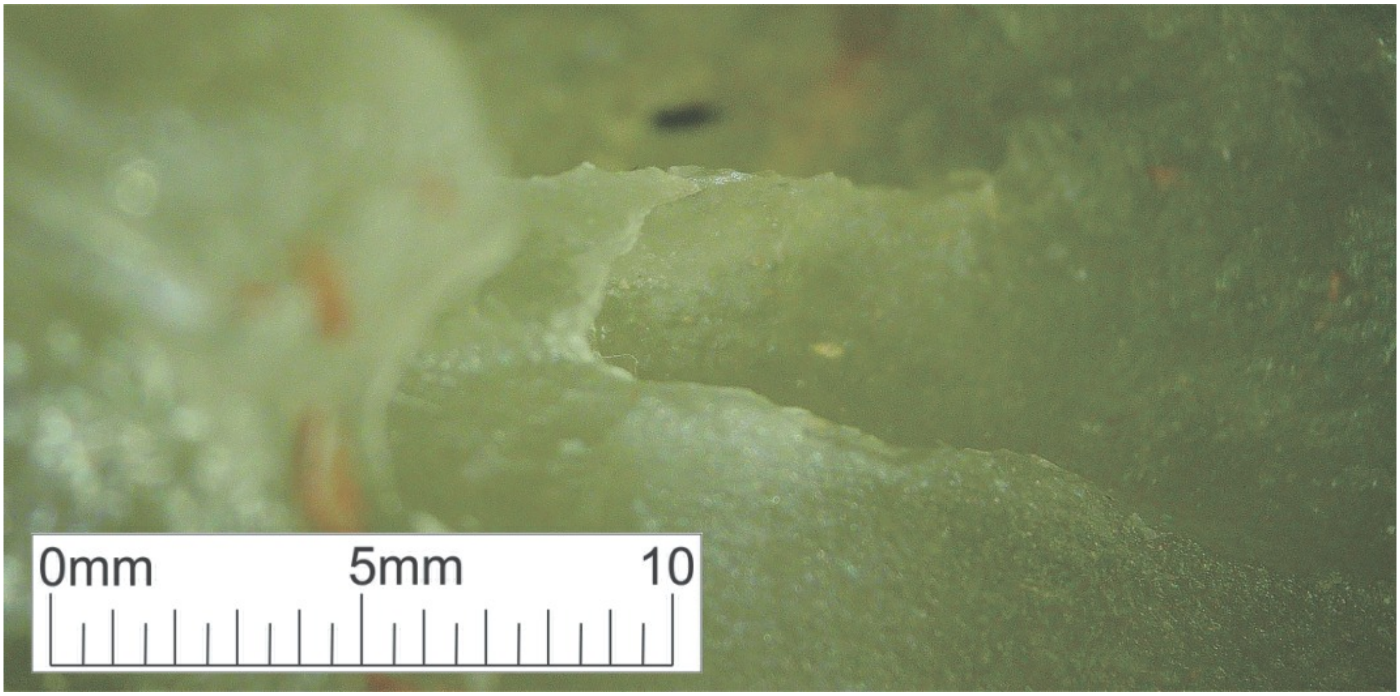
As the specimen tapers toward the E side, the A and B sides of this sample (above and below respectively) are solidly covered with circular structures which I have attributed to the ends of thread crystals. Given the alignment suggested by the flat face and the back side, this is where the threads are emerging obliquely. This gives four vantage points where the spaghetti bundle model seems to be appropriate. I found no conflicting striations on the piece.





Consider the fragility of the piece from the bisect images above. The purple marks the sliced rock connecting the halves, and the rest is unconnected. I chose the cut plane to show the most extreme span of unsupported material. The large cavity takes up most of the cross-section as viewed from either side A or B. The second main cavity (the apparent tunnel or stem cast) takes up a further sixth of it or so. It's remarkable that the specimen survived the collection process, not to mention life in the wild.

The image below looks into the main cavity. The blurry spot in the back is the smallest hole in the main cavity, the entrance hole to the nest. The blade-like edge at top center is the membrane between two nest chambers, probably broken when the large fracture opened up the piece. It is sharp enough to draw blood. Etching has perhaps played a role in keeping that edge sharp, but that's a noteworthy feature after some thirty million years in the wilderness.



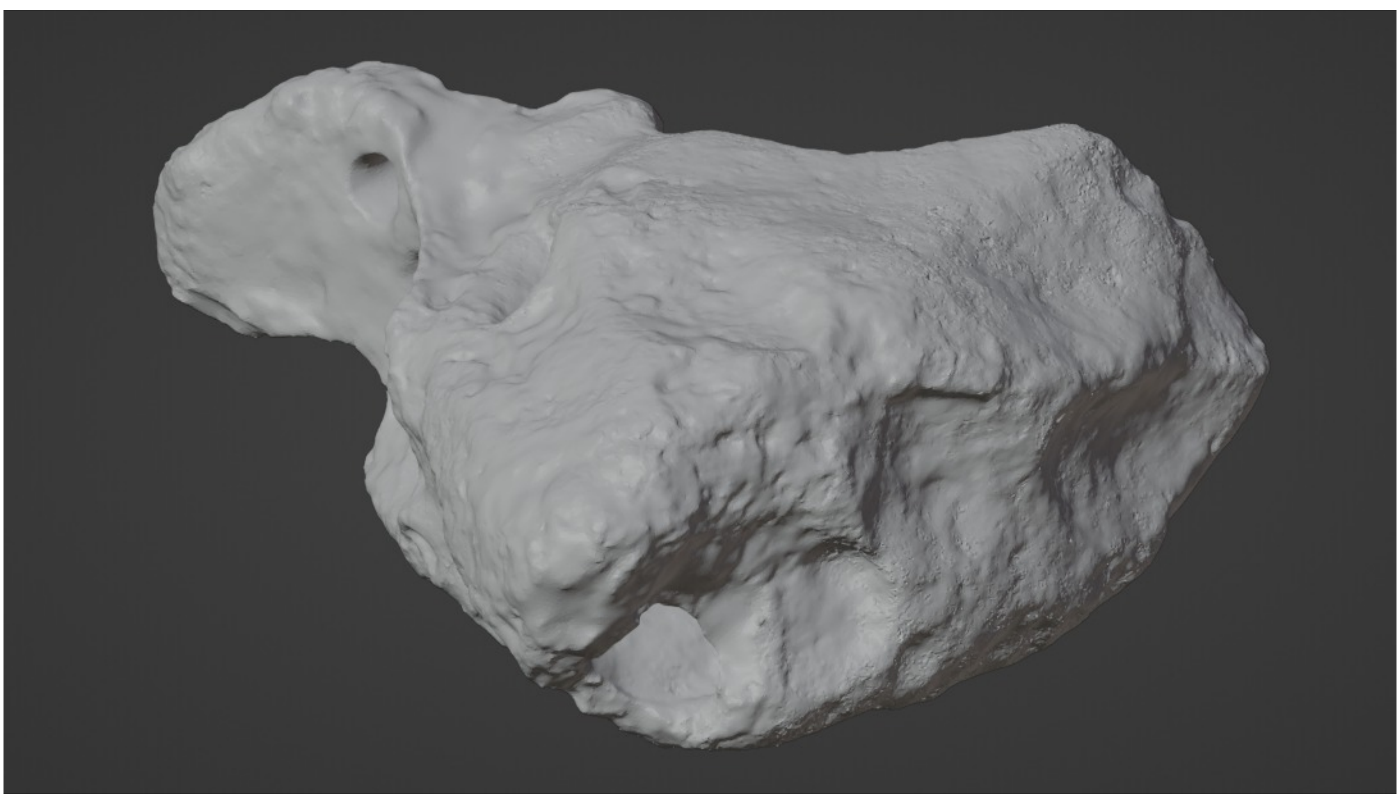
This specimen is phenomenally fragile. Some of this material must have been lost to chemical erosion, just as the threads were exposed by losing some of the surface. Even so, it is beyond belief that these cusps and bridges survived thirty million years in the wild. This cavity must have been more protected than it is now. Part of that protection would have come from whatever broke off leaving the large flat surface, but this still left considerable ports where sand and small pebbles could enter.

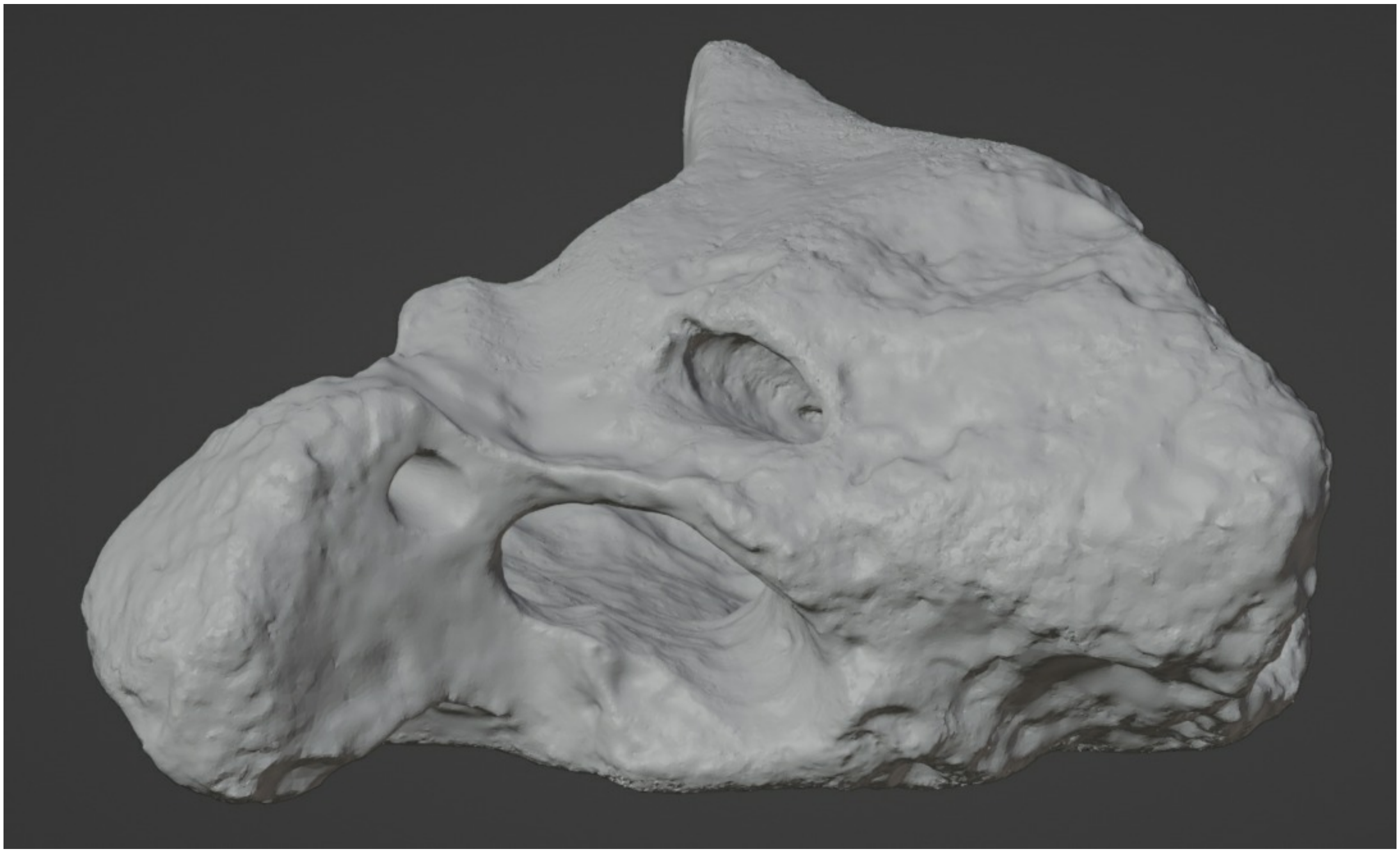
This means the A side (and some part of the C and E sides) had to have have formed a connection to a larger block. That larger block may have broken clean off this piece, or may have fractured multiple times, no way of knowing.

Further, the part which has now broken off is unlikely to have fractured early in this sample's lifetime. The fragility of the A side argues that those delicate arches could not have long survived naked to the world. The D side is heavily rounded as if the piece were tumbled along wadi bottoms. The A side had to have been protected from that. The blade-like chamber cusp could survive only if it was safely cradled in a well-closed inner cavity, preventing pebbles from washing in.

Most important, this amazingly fragile assembly with the sketchy cross section was where the piece DIDN'T break. When this sample broke off from some larger piece, this fragment riddled with cavities and glassware membranes was not even the weakest link.

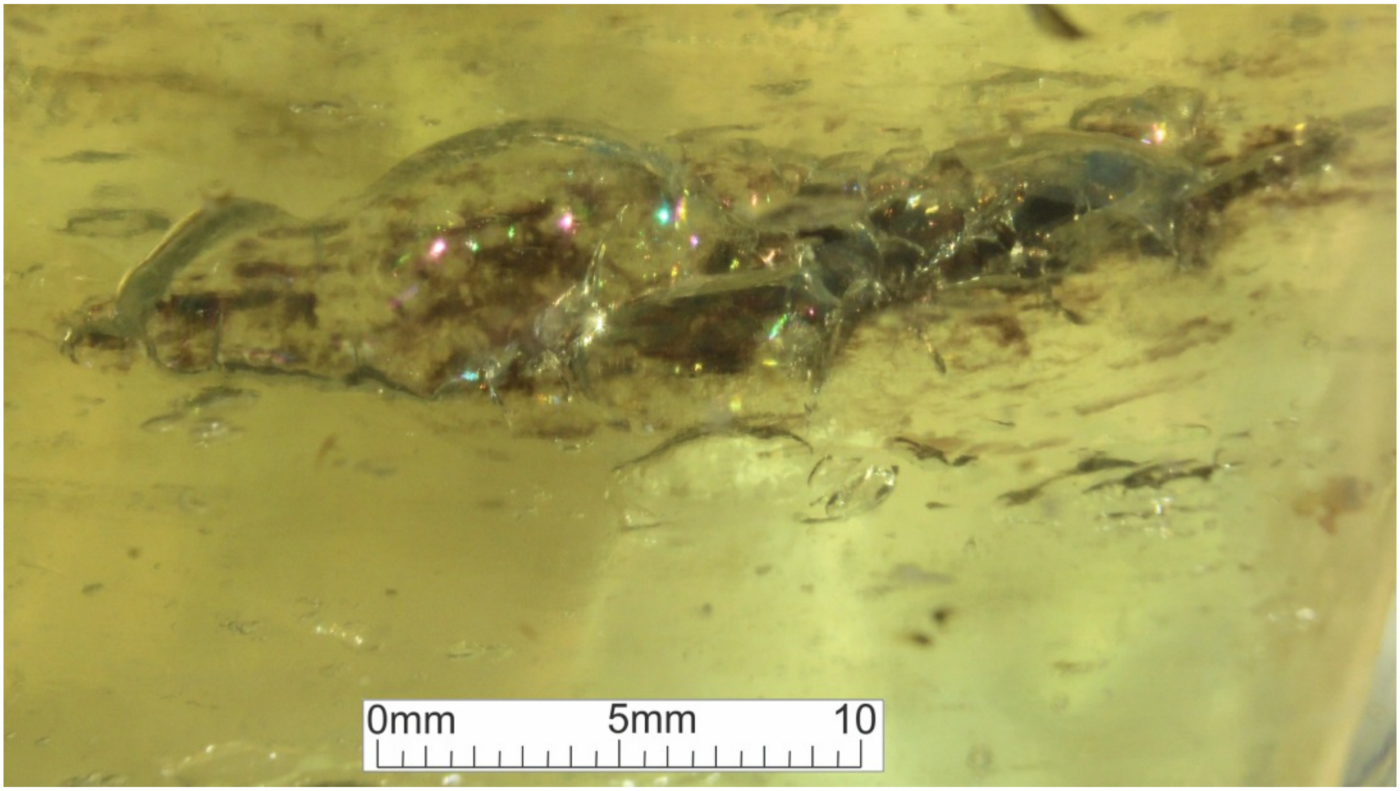
With that in mind, the image below should be interpreted as the remnants of more nest chambers, now beat-en down and eroded. The specimen that remains may be a small fraction of the nest that survived the LDG event.





With respect to my model, this piece again shows thread-like striations with a single consistent vector. Presence of those striations in the triangular island between chambers means the structure was there before the insects dug their nest. Where the apparent grain of those threads meets an oblique surface, it again shows circular pitting. There are no signs of layers, as were seen in sample LDG_03, but there is nothing here that conflicts with my hypothesis.

The most striking aspect of this item is not its support for my model but its fragility. There is no possibility that this specimen survived significant shock in the formative event. Beta radiation is the best explanation for the survival of this sample (and its larger and even more fragile parent object).



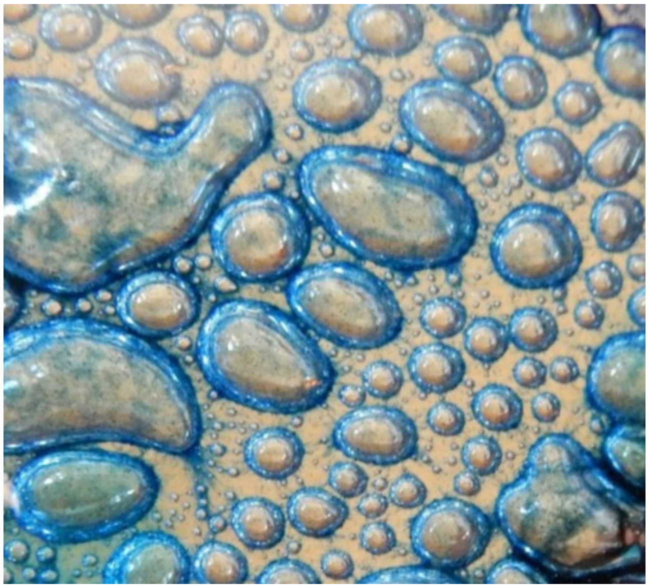
Bubbles

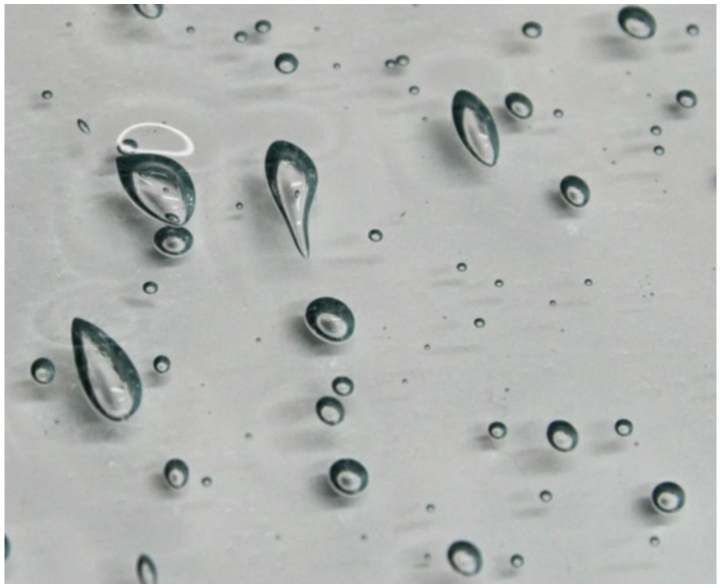
A bubble free-floating in liquefied silica, whether molten or irradiated, we might call Pelagic. The samples in this document, both presented and yet to come, seem to show that liquefied silica has very low viscosity and low surface tension. So pelagic bubbles should rapidly move up through liquefied silica and vent out, and should be relatively scarce in the samples.

By contrast, apparent interstitial bubbles are common here, along with bubbles which I will argue were interstitial for part of the formative event and then freed late in the process. These two groups provide two important kinds of evidence. First, by being not only interstitial but endemic, they argue that the formative event cannot have involved melting of silica. While we might envision some flash-melt that is so rapid, or that so delicately reaches a melting threshold that some grains survive, the overwhelming preponderance of these bubbles rules out melting entirely. Second, these bubbles are often aligned on an obvious axis. The bubbles in LDG point out the alignment of sand voids that captured them, and so are evidence for threads of grains.

The image above is from a sample not documented in an individual chapter. In this instance, a fibrous body was lying flat on the dune surface with apparent debris scattered around it, and became covered in sand. It had no stalk. In the formative event, the tuft (with air in it) was captured in a pocket entirely fluid, with no apparent sand grains. The air bubbles started moving upward through the fluid and were stopped when the liquid solidified, giving an obvious glossy and rounded classic bubble architecture like suds on water. If the liquefaction had lasted long enough, these would have broken free and risen as pelagic bubbles. Perhaps some already did.

Note that the bubbles aren't filled with water or silt, suggesting that this has been hermetically sealed beginning with the time of capture. In other words, this is probably intact biological material from the LDG formative event. This was imaged in a Karo Syrup bath.



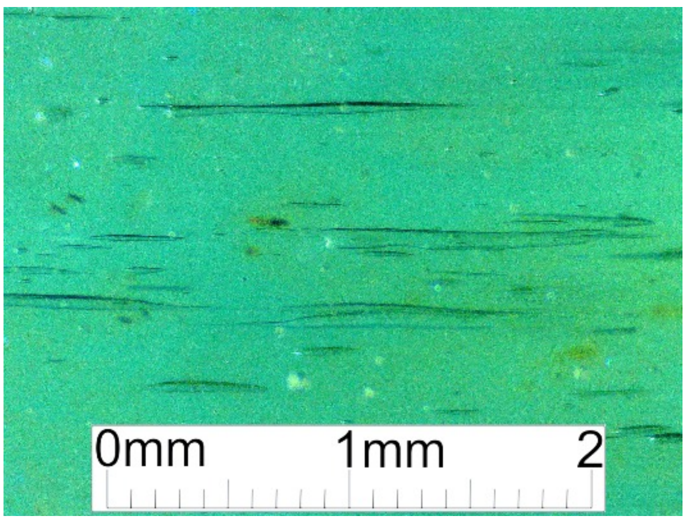


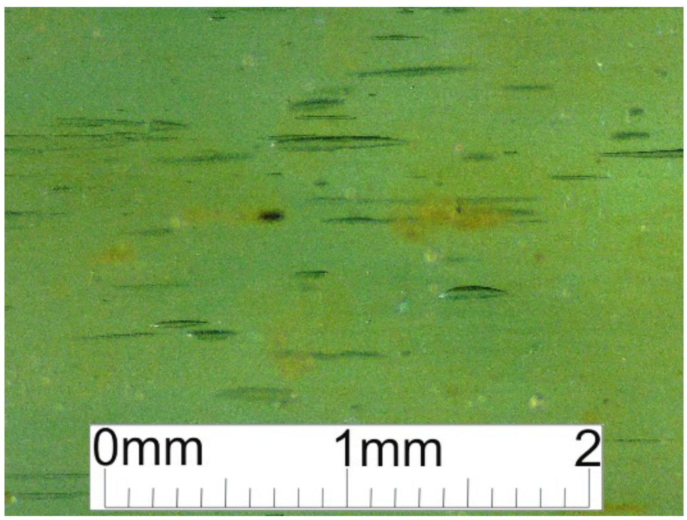
Above are typical bubbles in molten glass, found online. The ones on the left are stable, the ones on the right show some apparent drift.

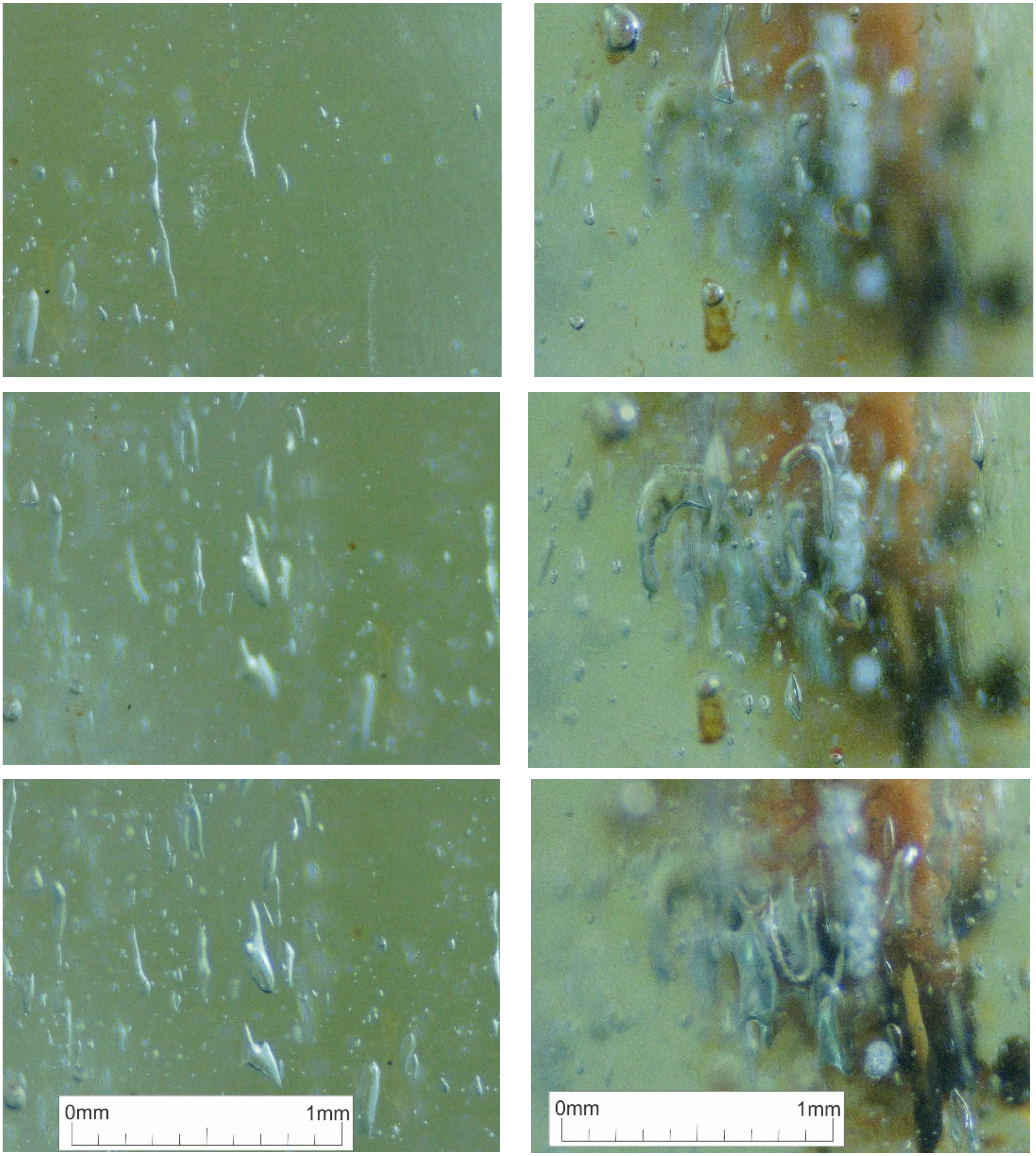
Below are bubbles from LDG_03, the first sample discussed above. Differences in color come from different lighting under the microscope, and I enhanced the contrast somewhat. The sample showed no obvious indication of flow, and the exterior surfaces were well-organized as if it were formed in place and undisturbed. These bubbles align to the externally visible striations.

The initial impression might be that these are stretched, but even if stretched the ends would be rounded as in the rounder ends in the image above right. The way to achieve pointed ends is at only the trailing end of a moving bubble, again as above right. The bubbles below are neither stretched nor have one trailing end.

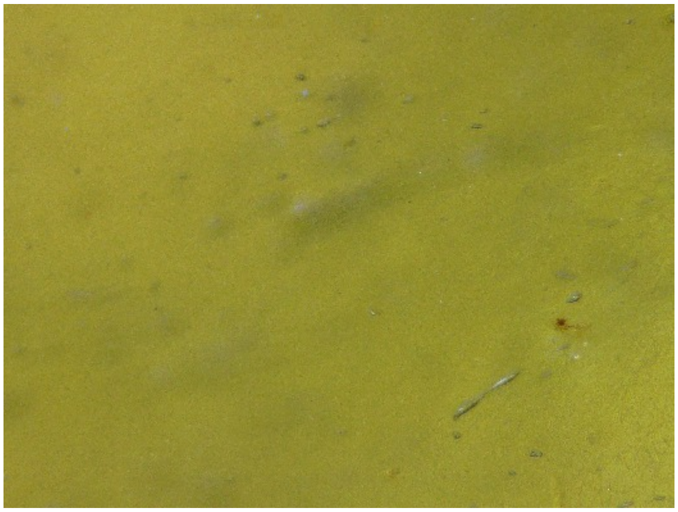
I propose that the formative event went something like this: As liquefied silica wetted into aligned (but as yet unjoined) sand grains, a sort of race went on between lattices. Radiation insufficient to destroy lattices permitted the liquefied silica to attach to and connect those lattices into long crystals. Air vented toward the surface except where these crystals trapped it, giving these distinctive thread-like bubbles. The sharp ends of the bubbles betray that these formed under constraint where long crystal walls met at shallow angles.

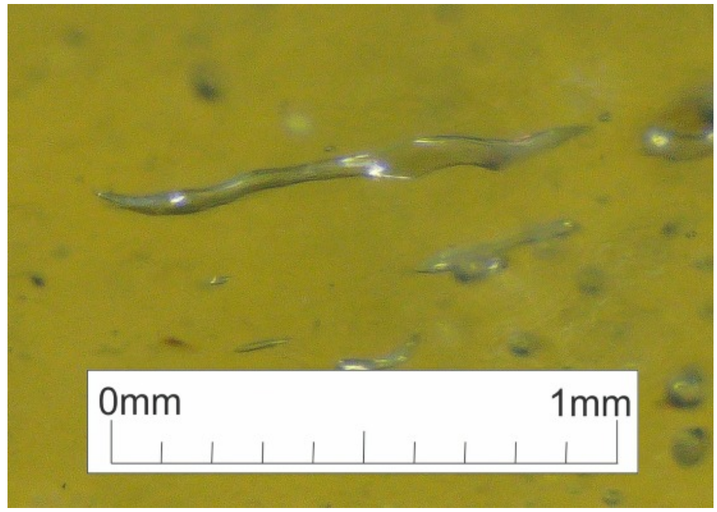


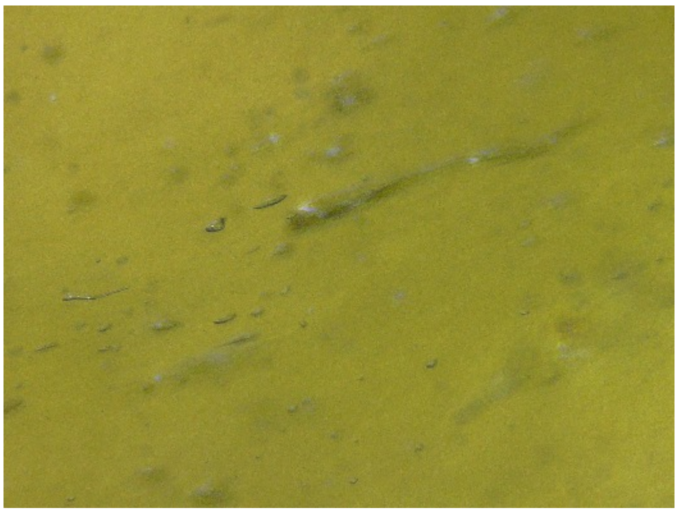




These two sets show the microscope focus moving down from the surface (top) to deeply embedded bubbles at the bottom. The top views show small bits of dirt on the sample surface, to establish the context. Given that Super KaroVision makes the surface invisible, this is the only way to ensure where the sequence starts when viewing the images. These images show more variation in the precision of the bubble walls, but the strong orientation is obvious again. Pelagic bubbles should be round.

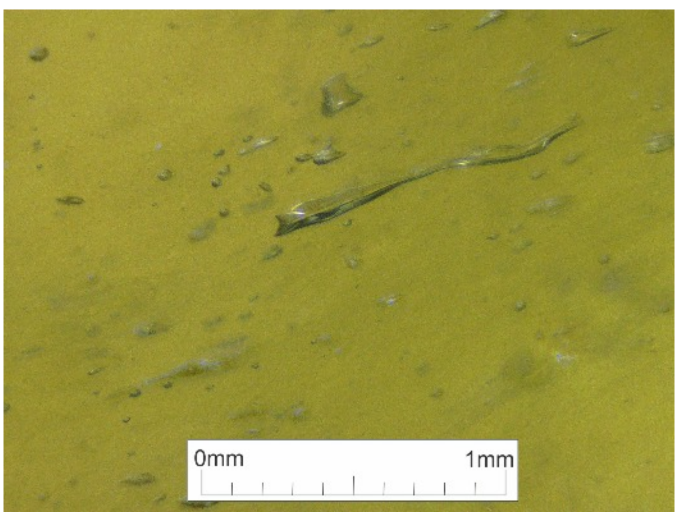


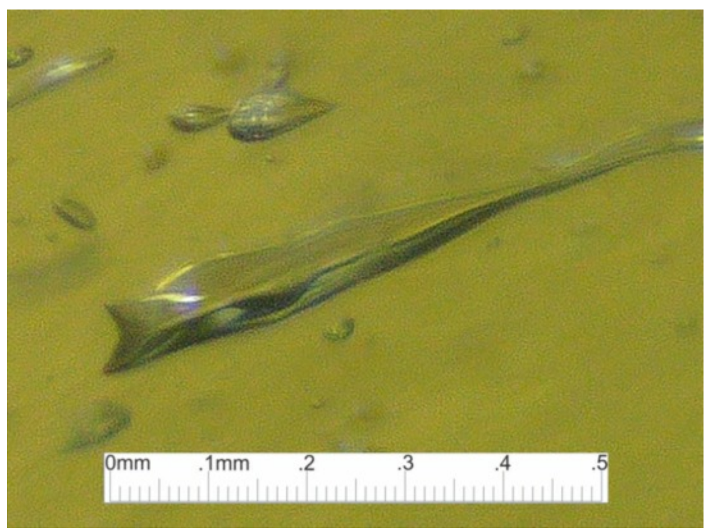


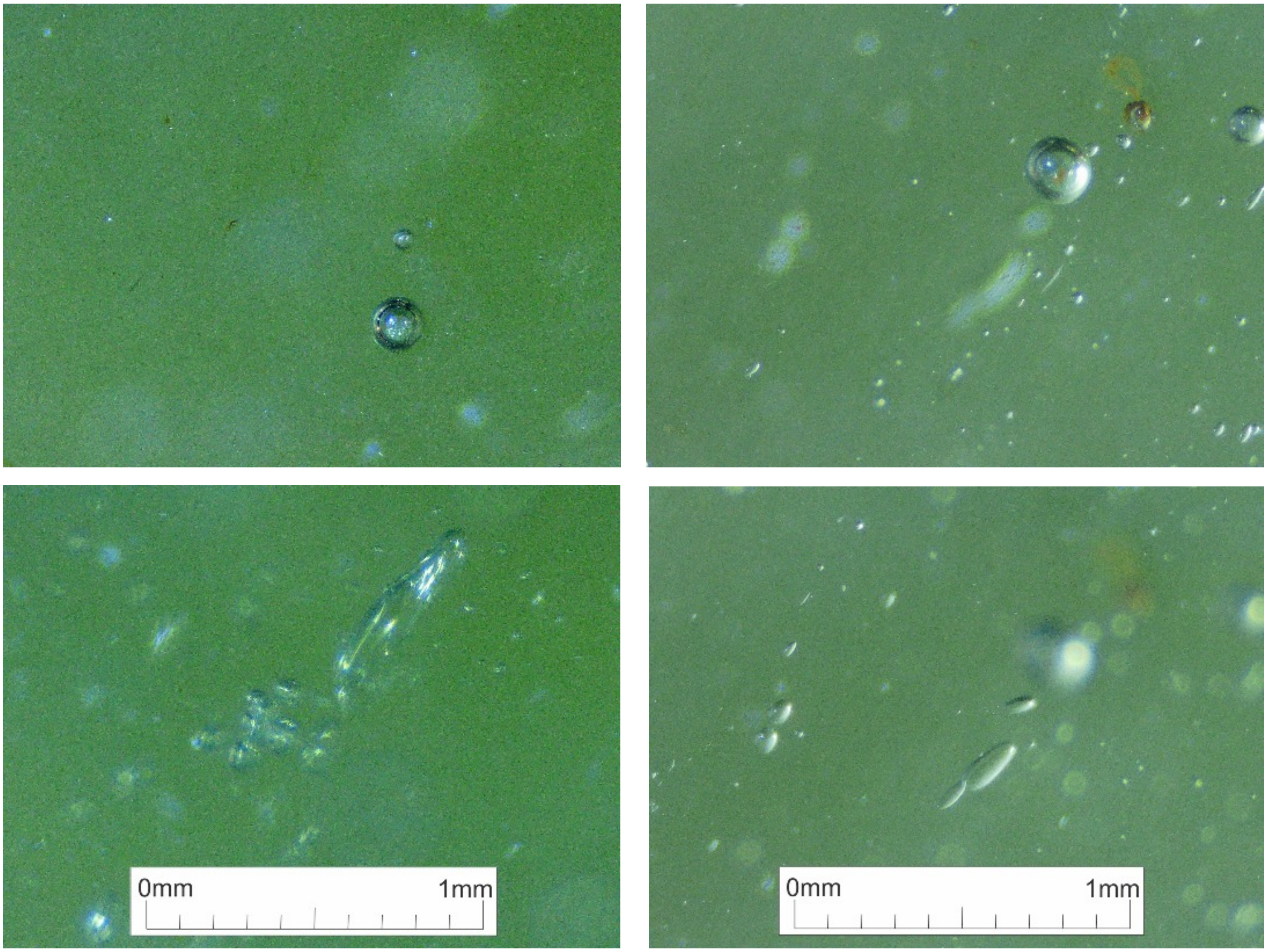


The image above shows another sharp-ended bubble, surrounded by similar ones. The sequence on the left is a progression from the sample surface down to the last bubble, and at each level smaller bubbles show the same orientation.

The close-up of the final image (below) shows how grains pinch off the left end of the bubble.

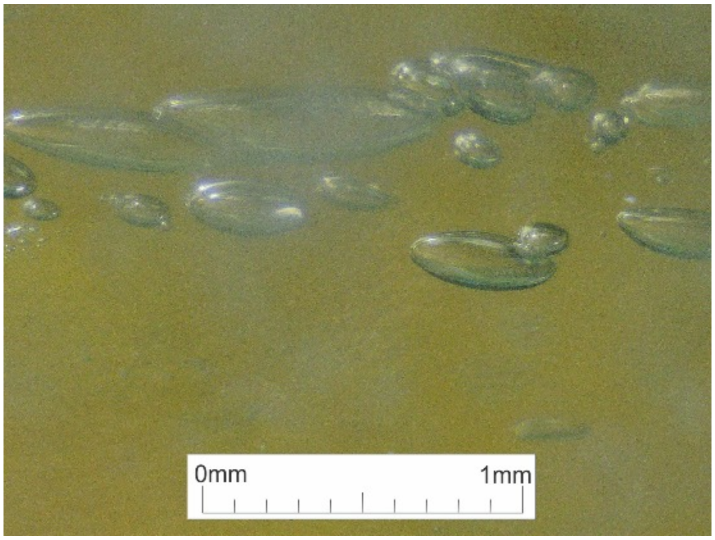


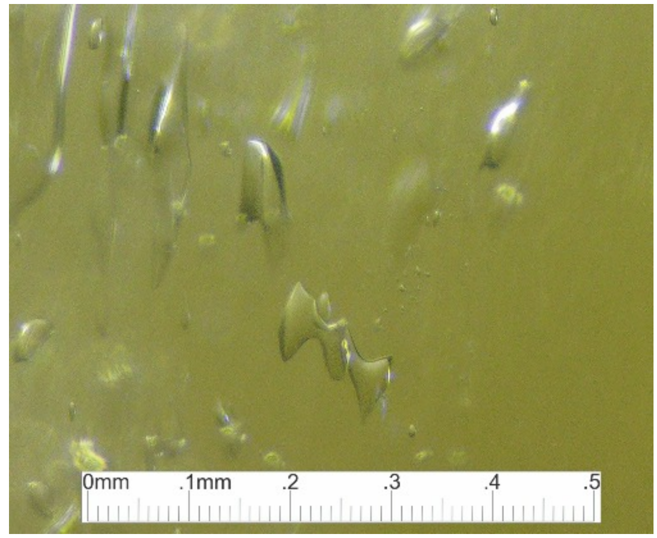


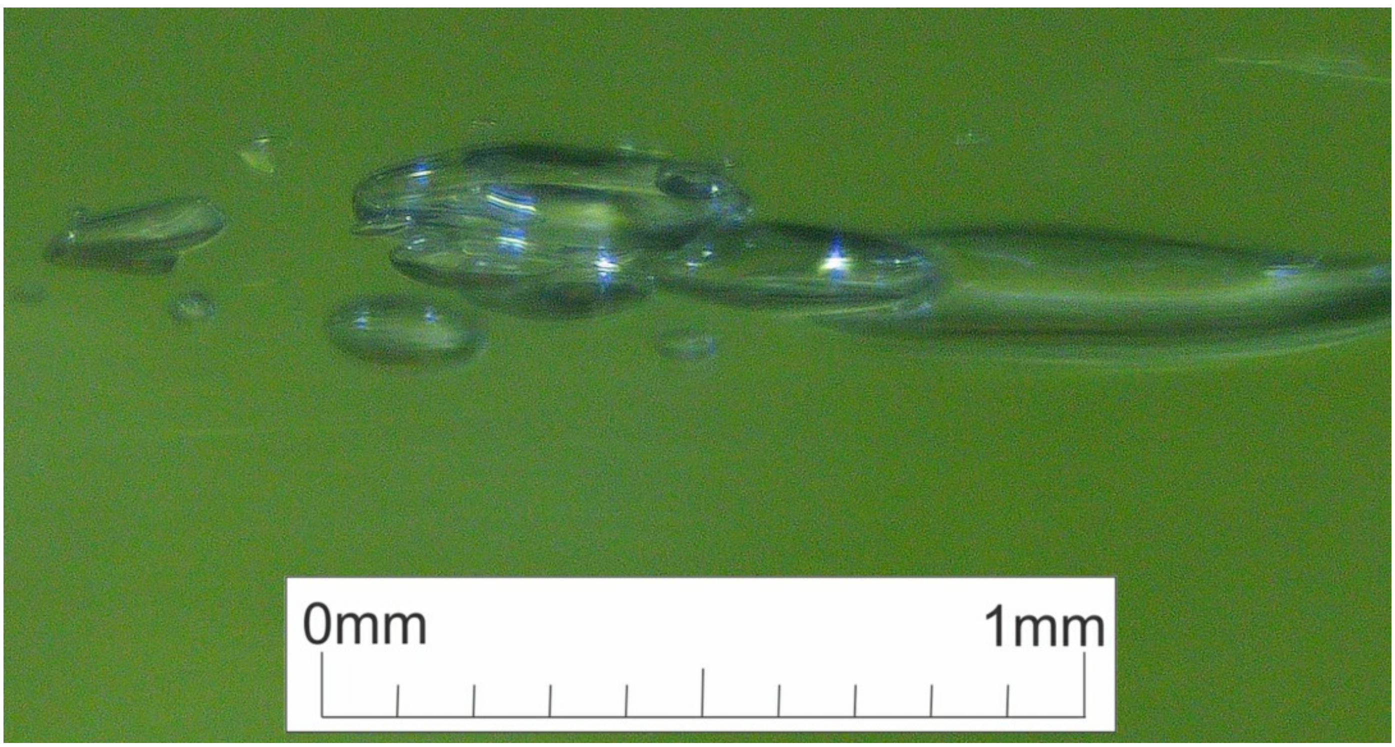


The spherical bubbles in the upper images are floating in the Karo syrup. Descending through the glass, there are relatively few spherical ones and many elongated. The elongated ones here might suggest silica flowing, if there were no conflicting context. But these sequences come from the LDG_11 sample which contains an apparent underground insect nest in a remarkable state of preservation, with no hint of distortion or turbulence.

That sample has external striations with an axis matching these bubbles. So I suggest these bubbles initially formed sharp-ended between the thread crystals, and the radiation duration and intensity disintegrated enough of those crystals to free these bubbles and let them relax toward a rounder shape.



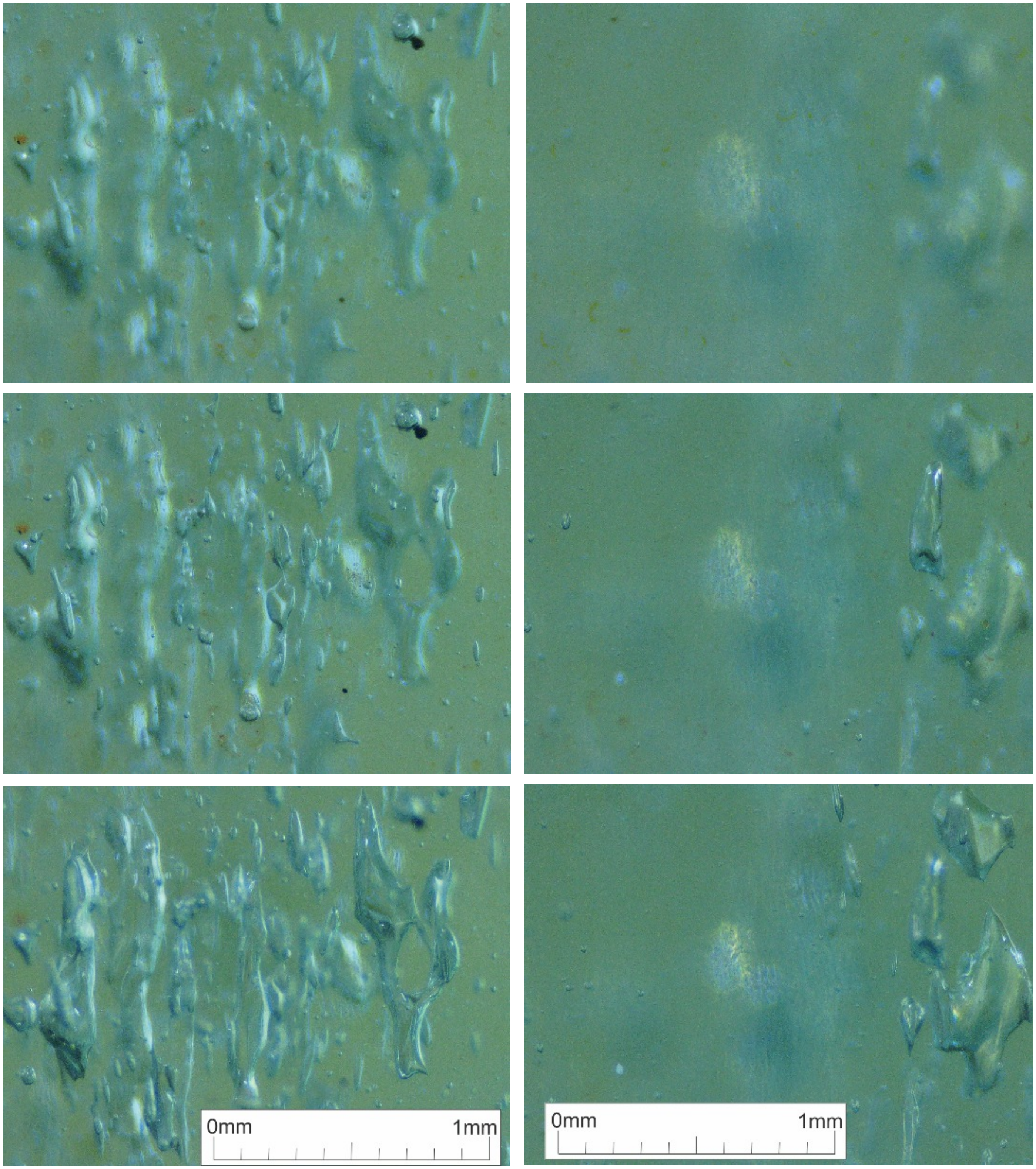




The same pattern again. Where bubbles are elongated, they tend to align.

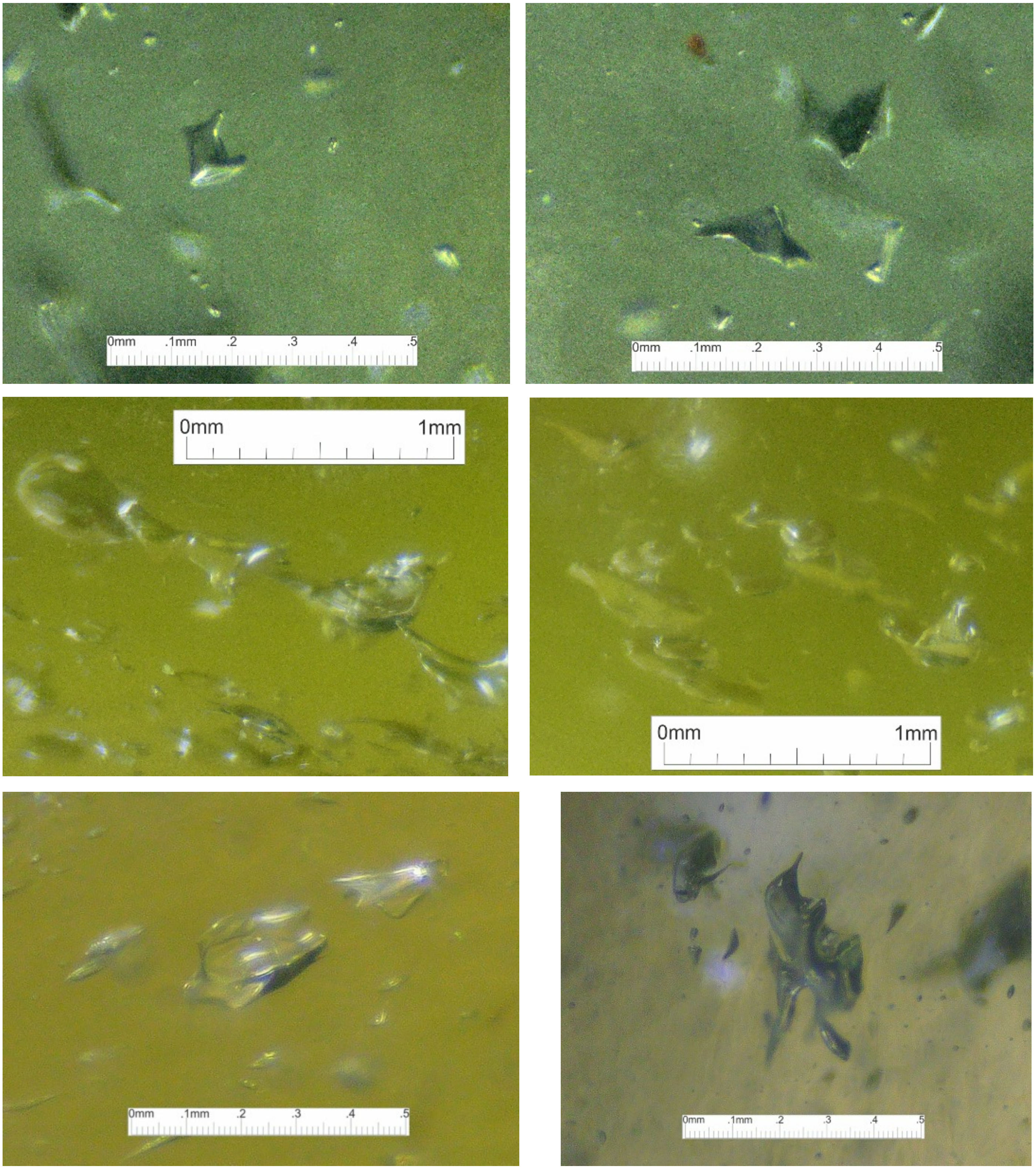
Something is impressing organization on this stuff. My thread thesis would suggest this alignment had to come from the sand. The bottom image in particular seems to show bubbles that are at rest. If these were once long and pointed, trapped between thread crystals, and have now been freed by progressive liquefaction, they should rise to the surface. So it's possible these are hitting a ceiling or thickening zone in the fluid silica as it sets up.

The saw tooth shape bubble in the top right image is interesting, and seems to represent multiple sand grains meeting to form that edge.

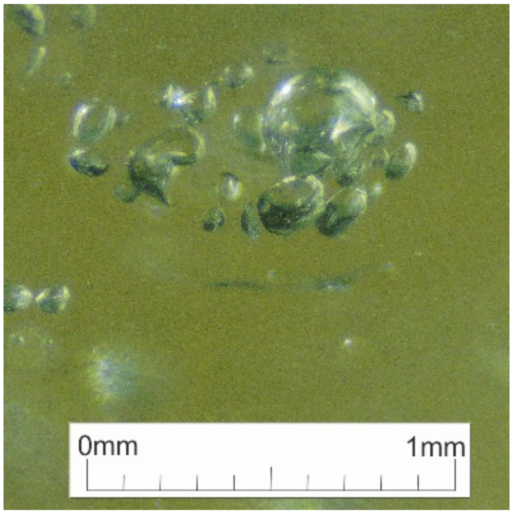


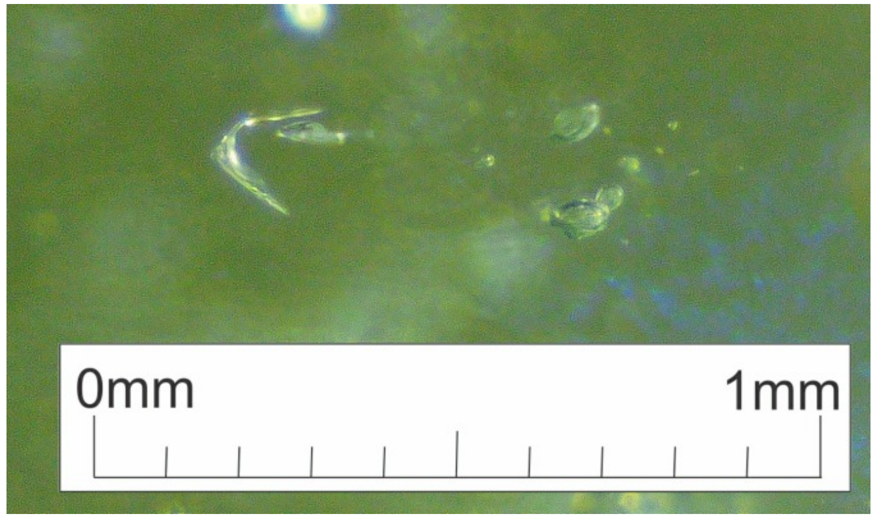
Even where individual bubbles seem chaotic, the overall alignment is obvious. The above images again work down from the top to the deepest I could conveniently image.

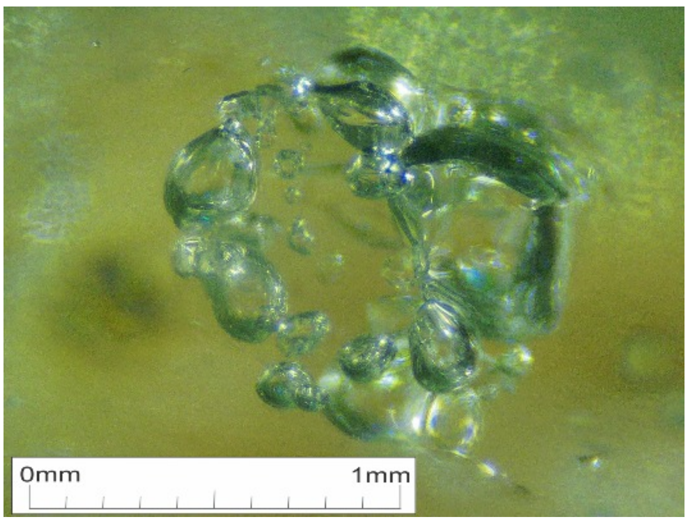
Not all sand threads will be laid in nice long rows. The pattern here suggests that there may be short and clumpy bursts. But even short segments illustrate more organization than should obtain from random grains falling on dunes. That being said, I don't know what story these bubbles might be able to tell.

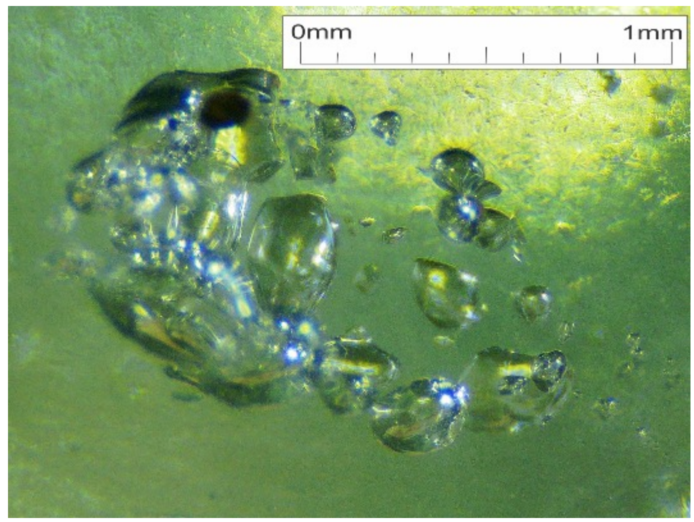


More commonly, we can see individual grains impinging on bubbles. The most important point to note here is the high proportion of flat surfaces. These are consistently cuboid grains.





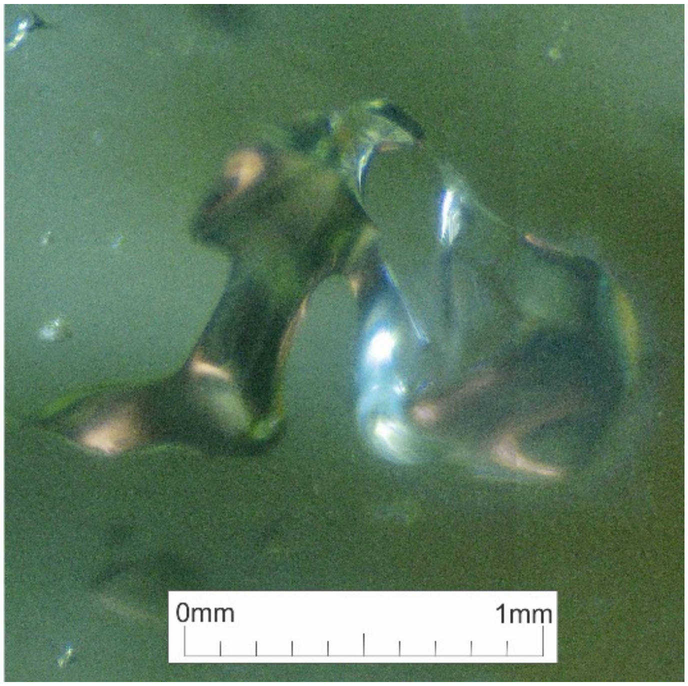


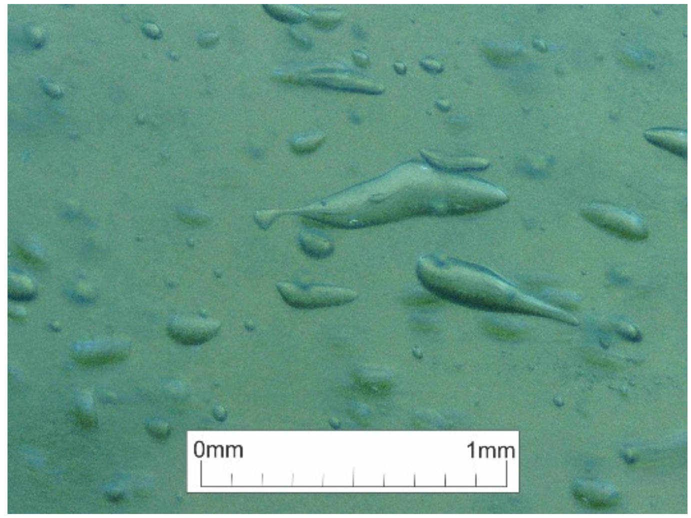


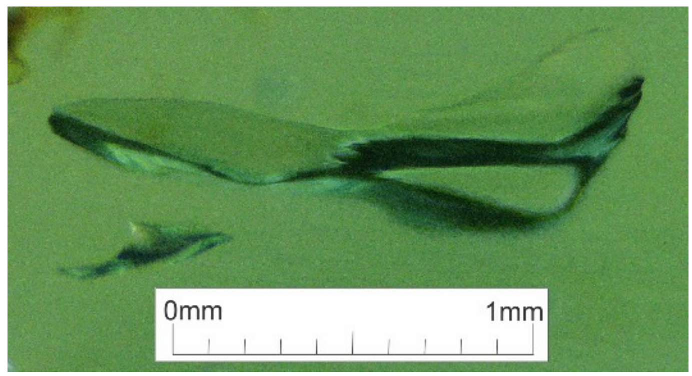
These rings appear to be the same phenomenon as scuba divers see; large air bubbles under the right condition will form rings rising to the surface. These rings can be continuous, or they break into chains of bubbles, but either way the result is a toroidal vortex.

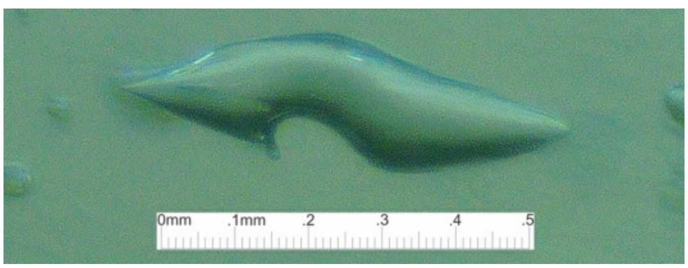
The top right ring is clearly spinning at the moment the liquefied silica seizes up. This demands a nearly frictionless environment, and for LDG it adds to the evidence that this is radiation-induced liquefaction and not melted glass.

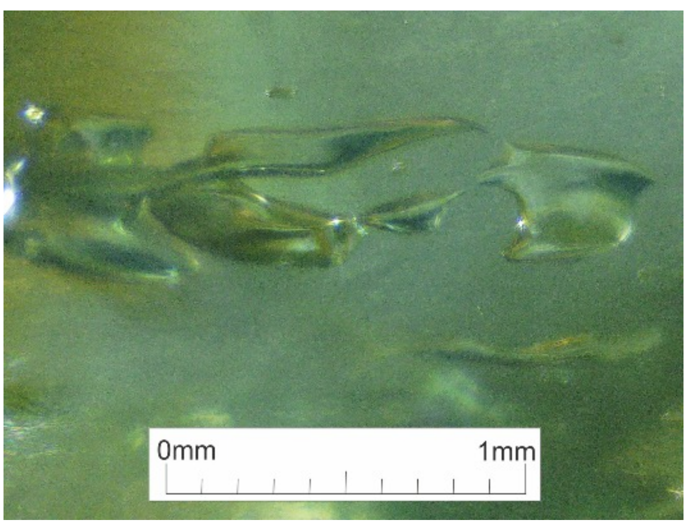
That this is happening in rings of about one millimeter could probably be used to extract meaningful values for viscosity, specific gravity and surface tension, but it's not my field. More generally, the fact that a fractional-millimeter bubble can generate enough upward speed to set up this vortex explains why there are so few pelagic bubbles in the specimens.

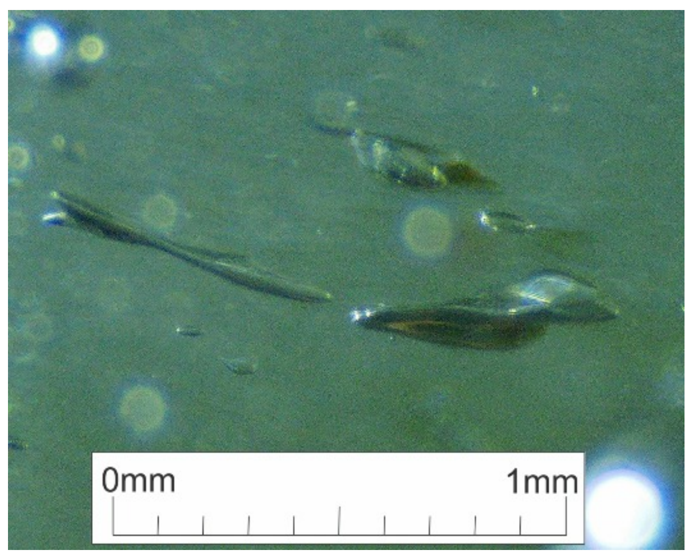






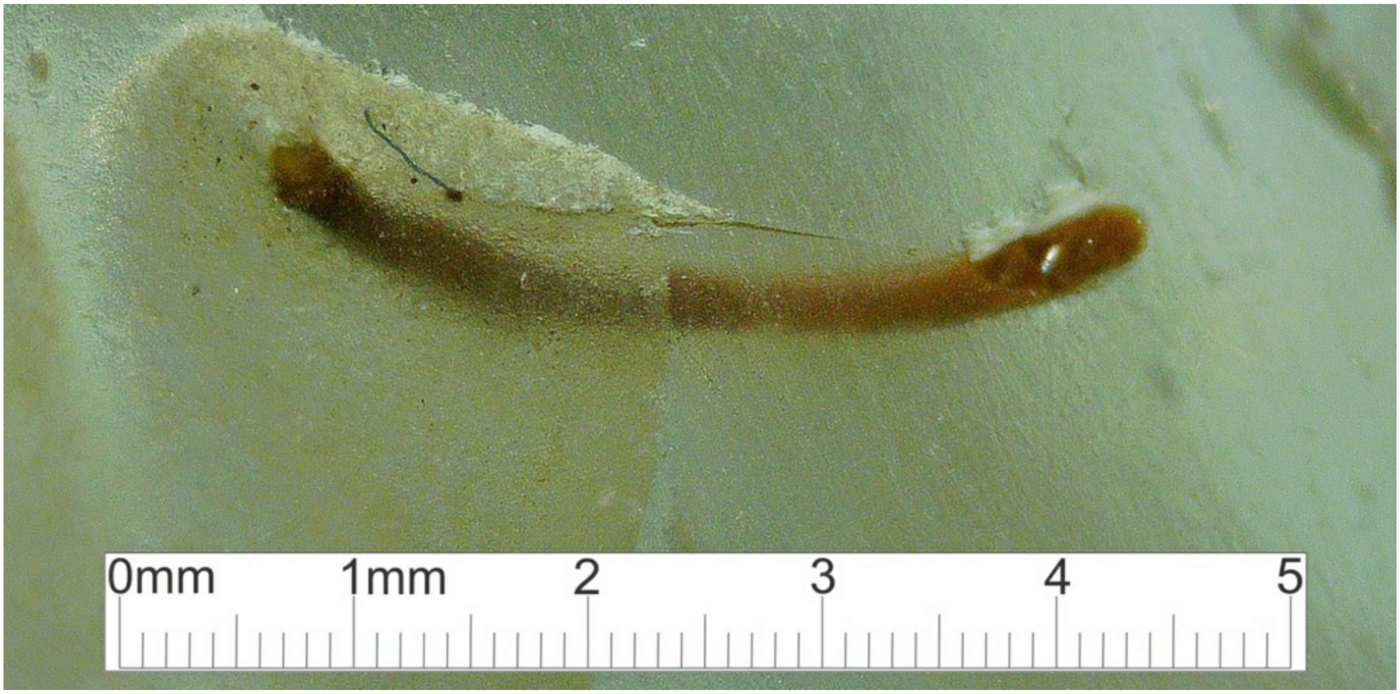






Some of the bubbles look like art. My favorite is the top right image showing a whale mother and baby, dating from at least ten million years before such whales evolved. But the point is that these complex bubble shapes should not be present. Pelagic bubbles should tend toward spherical, and these indicate there is some organization in the loose sand structure, or some unexplained force at work in the solidifying silica.

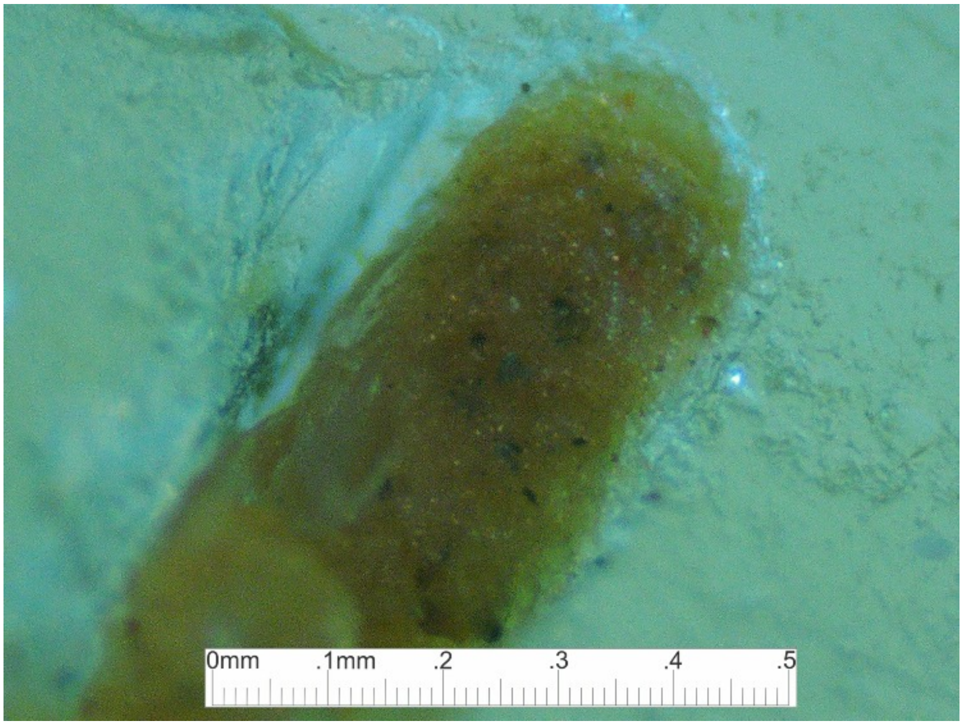
My inner child has more of these, but my inner editor gave me only one page to play on.

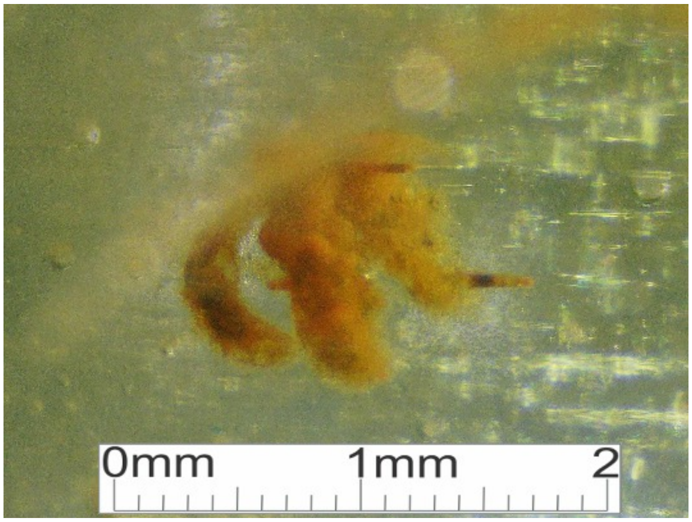


Microfossils

LDG is heavily populated with tiny fossils. These are various bits of debris that were scattered through the dunes before the radiation event. Some looks like it might be the disarticulated remains of animals. Where the microfossils contain biological material, they too argue against a heat event.

The item on this page appears to be some kind of berry stem. While cutting and polishing a flat side on a sample in order to get a better look at its internals, I found this had been cut through. It seems to have been completely sealed in the glass, and is therefore the original biological material. It has not shown any change or deterioration since I exposed it.



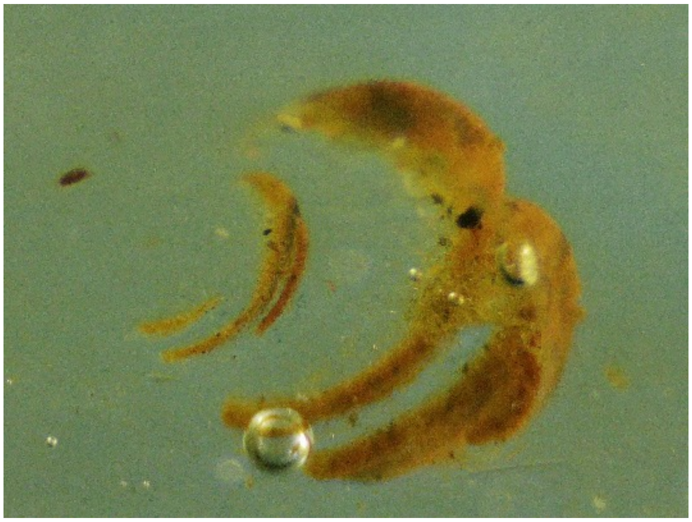


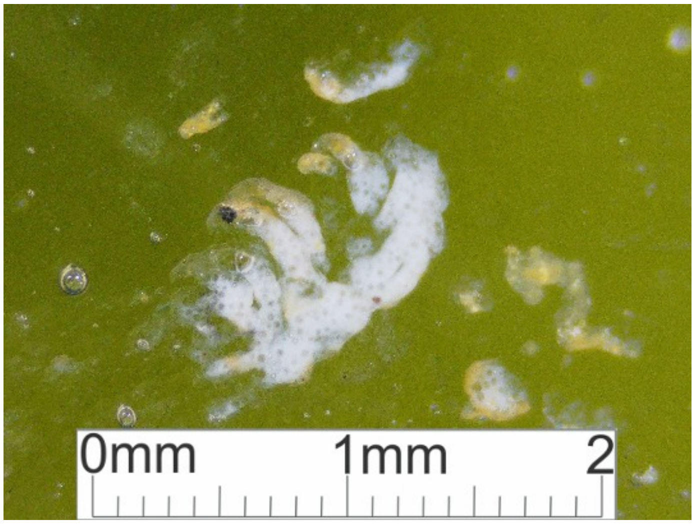
An assortment of similar embedded items is spread across multiple specimens. They are reminiscent of a dead spider with its legs contracted. These were buried in the sand before the formative event. If these are insect parts, they are disarticulated to varying degrees. They also might be husks of seeds from a plant I can't guess at. Seeds might grow in clumps, and the husks might shed singly and leave a sheaf of husks behind.

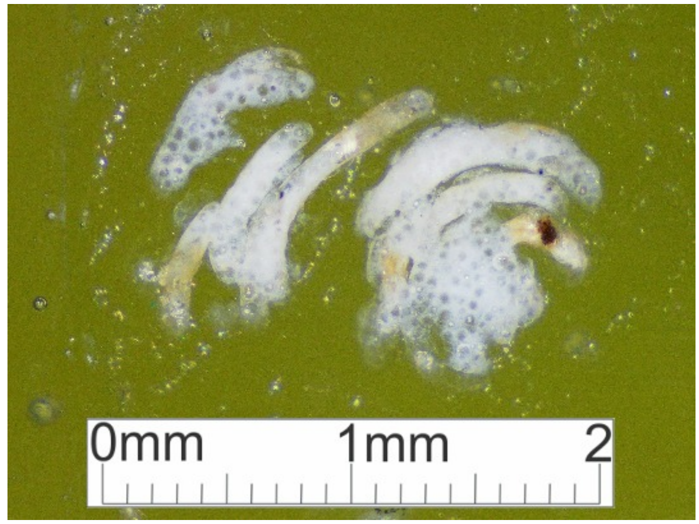
One of these cryptic items is shown above. The left view is focused on the specimen surface, the right is focused on the object itself, which is clearly a couple millimeters down in the glass. In the left image there is some difference in the focus on the upper left part compared to the lower right, and there may be a step down in the specimen there.

This raises an ambiguity. I'm not certain for the above object whether an edge in the specimen exposes the object to the air. So I'm not completely sure that this object is entirely encapsulated, and it might be showing a cavity filled with the reddish silt characteristic of the area. But the spider-like shape is clear enough.

The object in the bottom images has the same problem. This is right at the surface, and in the left image the round bubble right of center is in the Karo Syrup. In the right image I have drawn part of that bubble down to the left, to demonstrate that it was trapped under a lip of the object. I don't know that this is original biological material as opposed to silt. The smaller curved objects trailing off to the left appear to be entirely encapsulated, but I don't trust them. Again, whether silt or biology, the shape is clear.





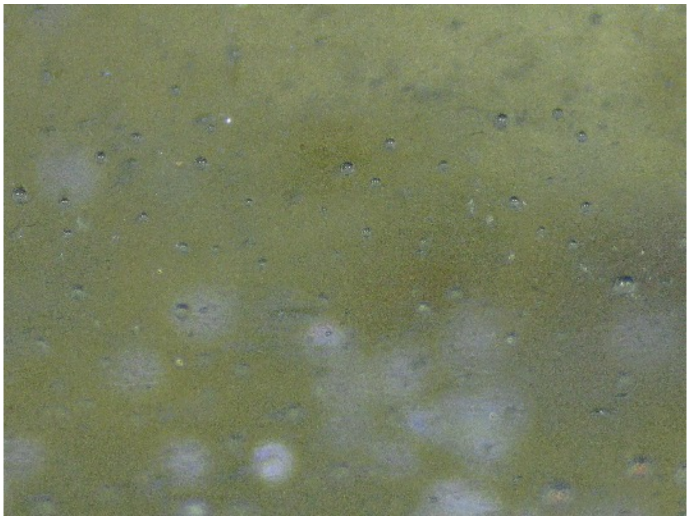


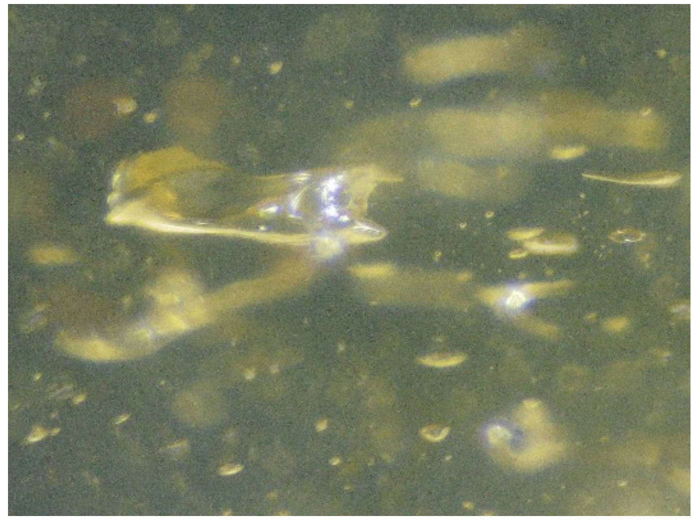
A suspicious group of objects resembles those on the prior page. The two above are in contact with the specimen surface, and trace amounts of the local silt add a brown color just where they open to the world. Farther down in the glass, they are white.

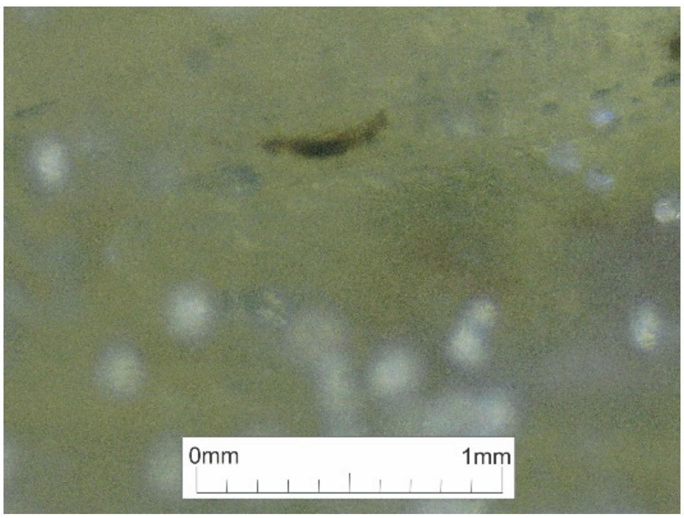
The white filling appears to be cristobalite in the form of many packed nodules, as shown in the lower right image here. This is commonly characterized as a high-temperature or devit product, but I suspect it is purely devit. In a few of my samples this material appears as dense clouds of single or paired objects, as short curved arcs, as well as more complex objects as shown here above or at bottom left.

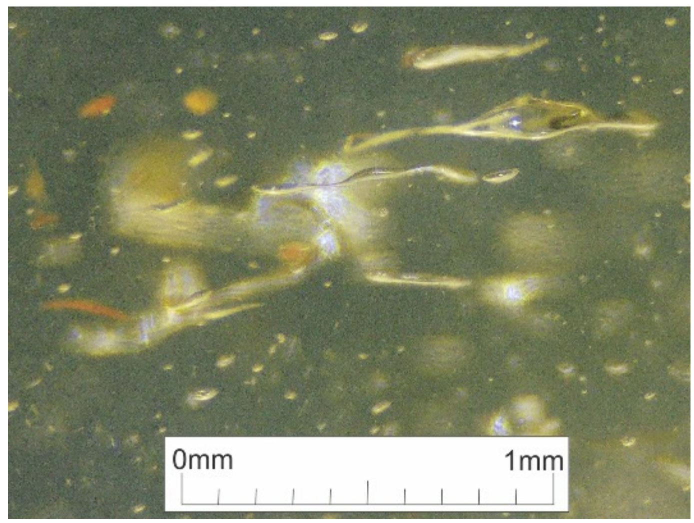
Devit of any kind might be considered entirely random in its location, but it likely starts with some seed or trace contaminant. It is not the devit that is random, but the seed upon which it starts growing. I suspect that the objects on this page began as those on the prior page, and something in their chemistry made them viable candidates as seeds for cristobalite devit. Just a layman's hunch, so take it for what it's worth. If that's what happened, then it adds to the tally of those objects, but still doesn't say what they are.

Alternatively, cristobalite propagates in small arcs for an unknown reason, and the similarity is purely coincidence.



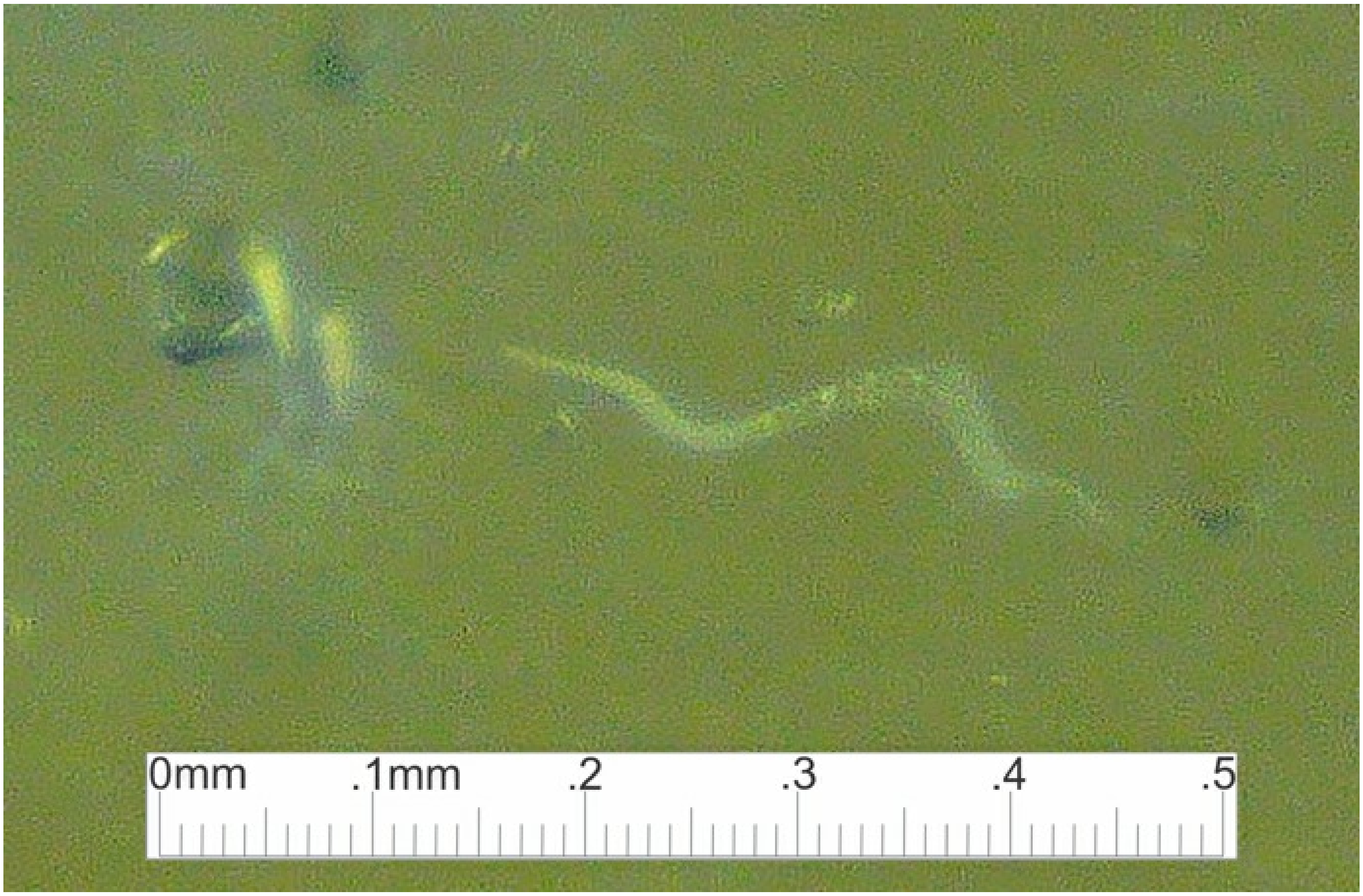






LDG is liberally salted with microscopic litter. Whatever might be dusted across a semi-desert is here. This includes plant chaff and insect parts too fragmented to be identified. They are encapsulated in the glass, and could be tapped into for chemical analysis.

The image pairs above start at the specimen surface to set the context, and the lower images are a couple millimeters into the glass. The left one shows an unidentifiable object, and the right one is full of brown specks. The color of the brown specs is close to the color of the spider-shaped objects a couple pages back, and is one reason to think those show genuine preservation instead of merely silt.



My final fossil appears to be a nematode. It's in the right size range, and seems to be a plausible shape. This is several millimeters deep in the glass, which makes it a bit murky. He was working his way around the individual grains of sand when the radiation event hit, and he's been stuck there ever since. Poignant, really.

Denouement

My collection is small; 26 specimens cannot cover the spectrum of Libyan Desert Glass. My probing is limited to what one can do with a cheap digital microscope and a garage-sale camera. There is a wealth of information here which I have not extracted. But there is enough to take the pulse of my thesis, and to pique interest in the radiation hypothesis.

LDG pieces with pronounced striations are common but not necessarily prevalent. The marks are easy to see at a gross level, and such pieces can easily be obtained. Similar pieces might be found from other locations. This is not about some quality of the Libyan Desert or a generalization regarding LDG, but about the dynamics of wind-blown sand which may be captured under lucky circumstances.

I listed three characteristics as evidence for my thesis. First, the crystal bundles will appear roughly like a handful of uncooked spaghetti. Any face might show no striations, but where striations show they will not conflict. Second, threads will not have progressive divisions. They will not form the equivalent of a delta or bush. Third, threads will not change vector to wrap around edges or cusps. All those bear out in my samples, but anyone is free to prove me wrong.

The evidence so far seems to raise a number of issues regarding the thread crystals.

Some fraction of the LDG flowed when fluid. This flow is compatible with both a heat event and beta radiation. Near the peak of the event the amount of flow may have been considerable. The record 800 kg piece may have been in a shallow declivity, and amounts to only a third of a cubic meter. It wouldn't take much of a slope to flow that quantity together. My sample LDG_07 shows flow, and the apparent thread-ends showing on all faces gives the impression of complete turnover and tangling of the threads.

One question raised by this sample is whether we're looking at the robustness of a crystal or the persistence of sand grain orientation. That is, did a sequence of grains manage during the fluid phase to link their lattices in a crystal that survived stirring although being bent? Or was there a sequence of grains lined up by my proposed process, which persisted even though the grains' lattices were not yet married? Are we looking at the flexibility of a crystal, or the ability of a medium to smoothly orient discrete objects? And if the second, what ratio of these discrete lattices were then oriented well enough for devit to merge them, albeit somewhat discontinuously?

Another strength-of-crystal issue is shown by the tendency for samples to fracture into flat faces covered in striations. That is, the crystals appear to be guiding the fractures of the pieces. Sample LDG_03 showed what appeared to be a well-melted top surface matched by a completely striated underside. The crystal strength was apparently enough that the slab break aligned with the crystals, and when it broke across the grain it shattered like layers of plywood. The only minor side wide enough to be called more than an edge showed continuous striations again, suggesting another preference plane (unless it was my hypothetical varves).

Sample LDG_05 showed the same heavy striations. It would be unwarranted to say there is any special property of the A or B face that led the rock to fracture *at that point*. It is rather the orientation of the cryptic structure that is being disclosed by weathering, once each of those faces is exposed. A fracture parallel to A or B that removed either more rock or less could be expected to give the same striations.

When the cryptic structure is consistent, when enough threads are parallel, such a structure appears to drive the tendency to fracture on a given plane. Any other facet orientation is left to the luck of impacts or perhaps inclusions. When sample LDG_05 was broken by an impact that couldn't take advantage of the A/B parallel crystals, perhaps the next most-populated plane of the E face set the angle, as a record of variable winds. When there are not enough crystals to define a fracture plane, the surface will be butt or oblique ends and will display either no special detail or perhaps tell-tale circular features.

If this is valid, if my concept is correct, then the built-up layers and threads here frozen in glass should be thought of as statistical records of breezy days. Like any sand dune, a deep-enough specimen of LDG might contain the layers of variable winds. This suggests an experiment. A disk of LDG could be cut with a vertical axis, and its edge then etched to reveal possible striations. These should appear and disappear in segments around the disk as the edge goes tangent to them. They should also mirror on opposite sides. By their density and relative direction, these would indicate the variability of winds as experienced by this sample. If the sample has any magnetic signature, even the compass direction of winds might be read off.

Bubbles turn out to be as intriguing as the striations and threads.

Of my 26 specimens, 23 have noteworthy bubbles, and most of those are represented here. The most common inclusions seem to be bubbles and cristobalites. Bubbles contribute information in two ways: They define the structure of the LDG and the constituent grains, and they give a window into the dynamics of the formative event.

Bubbles shown in sample LDG_08 and in the chapter devoted to bubbles tend toward cuboid grains. This disagrees with the common wisdom that desert sands will be well-rounded. I have no response to that aspect. But it is intriguing that we find cuboid grains in the glasses that show the apparent electrostatic grain-stacking. I don't know if the prevalence of that stacking in LDG owes anything to the cuboid grains, but it's an interesting idea.

Further, the extremely long and pointed bubbles suggest they are being constrained by the long crystals I have proposed. The internal structure implied by those bubbles matches the external striations. Additionally there are bubbles with shapes that I can only call exotic, where the default should be spherical. They don't seem to envelop sand grains. I can not suggest their back story.

The bubble size is striking, with few over 1 mm in their longest dimension, one of those being the lead image in the Bubbles chapter. The typical volume might be about 25 micro liters, a fraction the size of bubbles thrown off in a carbonated drink. Yet bubbles of this size can rise through liquefied silica fast enough to set up a bubble ring with an overall diameter of about one millimeter. This suggests the fluid silica is far less viscous than water.

When I have presented images of the insect nest in LDG_11, with a volume of perhaps five cc, it has been dismissed as a bubble in molten glass. But the evidence from a wide selection of LDG bubbles suggests that none can get close to that large.

Finding beta radiation's role was an accidental product of researching my thesis. This was something of an epiphany, when melting seemed increasingly unlikely sample by sample. It occurred to me that it would be convenient if beta radiation could liquefy silica, so I looked it up and there it was. Having started firmly in the molten-sand camp, it took a while to get my arms around the radiation hypothesis.

This puts new questions on the table.

One is the depth attainable by beta radiation. It normally is stopped by a thin aluminum plate, which may translate to an inch of soil. But it doesn't travel far in air either, and the event required to generate LDG must have been a massive saturation. I posed the prospect of this being a micro-nova or super flare focused by a wandering North Pole, as we are seeing in progress now. The question then is what environmental conditions might deliver this to ground level, and how deep the saturation might go over what interval. Such an event must be rare, given that we have only one example.

A second is the viscosity and behavior of beta-irradiated silica, and whether this is a simple state change or varies over a continuum. How susceptible it is to capillary action, and how much that action depends on the beta particle saturation, will inform how far it can soak into the sand, and how far it might move laterally and then soak up in a column. We need a wetting model for fluidized silica during and after beta radiation.

Another question is the possible effect of electric current or beta radiation on crystal formation. My flowed sample LDG_07 has what I take to be crystal butt ends on all of its faces, and some of these are quite large. Striations on some samples are on the order of 0.1 mm, but the circular scars on LDG_07 are up to 1 and 2 mm. An open question with regard to that sample is whether the crystals formed in the melt or by devit later. For any crystal that exists within a fluid body, there is no equilibrium. If the fluid is excited enough, the crystal lattice will break down and vanish. Otherwise the crystal will grow.

If the mass was disturbed enough to leave relatively few intact seed lattices in more-or-less organized chains, then each contorted crystal would have had few competitors for the unattached molecules around it. So the question is whether these very fat crystals can be attributed to (1) devit in a rich environment or (2) very rapid growth in the fluid, perhaps agitated by flow, and (3) perhaps turbo-charged by an electric current or beta-particle bath.

A related issue is the zircon. Its formation has historically been exclusively considered a high-pressure phenomenon. I find no mention of experiments with electricity, but zircon has been discovered in conjunction with fulgurites, and a paper on the subject holds that high pressure can no longer be considered a requirement for zircon formation. I am not aware of any description of the physics involved in a lightning strike that would create zircon, or the implications for reidite. The possibility remains open that the zircon and other meteorite indicators were salted into the LDG area as part of the strewn field from either of the two known nearby impacts or some other. A recent paper describes many impact sites in that same area.

The loose sand which became LDG is gone past recovery. We can no longer test it to see how much zircon or reidite was seeded into the area before the LDG event. But LDG also contains sandstone, and that portion must predate LDG. So tallying the presence of zircon or reidite in LDG containing sandstone, as compared with sandstones from outside the LDG strewn field, might give useful information.

Regardless of the candidate explanations for seeming high-pressure evidence, I submit there is less cognitive dissonance if we accept the radiation hypothesis at ambient temperature and have to resolve the pressure question than if we accept the heat-and-shock hypothesis and have to answer for the crystals, fossils and bubbles.

We need a model for the radiation conduit. I have proposed that it results from the cloud of constantly rebounding low-energy particles, when they finally break through at a point of earth contact. Does the radiation punch a small hole, as lightning is a tiny conduit for the cloud whose charge it adjusts? If the newly formed LDG were six inches deep, it would cover fifteen square miles. How long might it take for the pressure to relieve, and what is the intensity of beta radiation over time? Would it behave like a lightning strike, establishing a contact and then remaining open on a path of perhaps ionized air for some period of time? Or might it behave more like a severed air hose, whipping randomly?

Or perhaps the beta radiation was from another source entirely. The LDG formative event must have been highly unusual. A plausible cause is the weakened magnetic shield and the wandering pole, but these happen every few thousand years. If this were a regular part of that process the earth would be painted solid with this stuff. At least LDG shows that vitrification by beta radiation is possible, even though the direct cause is uncertain.

With that in mind, we might ask if this sheds any light on other sites.

Tanis in the Nile delta was the capital of Egypt during two dynasties; its river is now silted up. Melted and scarred statues are reported, damaged presumably by high temperature of unknown origin. Vitrified hill forts in Northern Europe have walls with partly melted stones and no good explanation. Attempts to recreate or model the effect with fire have been unsuccessful.

The Indus city Mohenjo Daro and its entire civilization were apparently in decline when some event laid waste to parts of it around 2000 BC. There are enigmatic and chaotic skeletons: Men, women and children seemingly dropped in their tracks with no sign of wounds, their bodies undisturbed by scavengers. The Rig Veda, the earliest book of India, tells of the god Indra raining down fire. Bricks and pottery show vitrification as if exposed to extreme heat. There are no indications of war, no involvement of the city's citadel, no warriors in armor, no weapons broken in battle. Various stories have been run out to explain it, from bandits to nuclear war, but the site remains mysterious.

It's early days for the radiation hypothesis; my case needs vetting. Early days too for my grain–stacking thesis; I haven't seen this suggested before.

There is no reason to think that the dunes which became LDG were different from sand dunes anywhere in the world. If I'm correct about stacked-grain crystals, then this thread-building process is the natural behavior of blowing sand everywhere. Libyan Desert Glass merely makes it visible.

Credits

North Magnetic Pole excursions Liu, J., Nowaczyk, N. R., Panovska, S., Korte, M., & Arz, H. W. [2020]. The Norwegian-Greenland Sea, the Laschamps, and the Mono Lake excursions recorded in a Black Sea sedimentary sequence spanning from 68.9 to 14.5 ka. Journal of Geophysical Research: Solid Earth, 125, e2019JB019225. https://doi.org/10.1029/2019JB019225

Paris Natural History Museum LDG specimen Wikimedia URL: https://en.wikipedia.org/wiki/Libyan_desert_glass#/media/File:Verre_libyque,_exposition_%22M%C3%A9t%C3%A9orites%22,_Mus%C3%A9um_national_d'histoire_naturelle.jpg CC-BY-SA

LDG Strewn Field Map from C. Koeberl and L. Ferriere: Libyan Desert Glass area in western Egypt: Shocked quartz in bedrock points to a possible deeply eroded impact structure in the region, 2019

Kelso Dunes from National Park Service URL: https://www.nps.gov/thingstodo/hike-the-kelso-dunes.htm

Sahara Lakes Unknown

Verves Sosjon https://letterstocreationists.wordpress.com/2019/03/04/annual-layers-varves-in-lake-sediments-show-the-earth-is-not-young/ from Source: Zillén et al, Boreas, Vol 32, Issue 4 December 2003 Pages 612-626

Layered Sandstone Unknown stock

Petrified Dunes crop from URL: https://thenaturalhistorian.com/2013/08/07/nh-photography-petrified-sand-dunes-near-moab-ut/ Joel Duff

Sandstorm Lightning crop from LiveScience.com https://www.livescience.com/8195-mystery-sandstorm-lightning-explained.html

Blowing Sand 1 cropped from web https://www.josephfiler.com/photo/california-death-valley-desert-sunset/

Devonian Sandstone Layers cropped from web URL: https://www.flickr.com/photos/14508691@N08/45606301901

LDG Fractured 1 Ebay sale item

LDG Fractured 2 Ebay sale item

Pitted Moldavite Online sale

Pitted LDG 1 Online sale

Pitted LDG 2 Online sale

Zebra Slot TripAdvisor